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OF THE

TEA RESEARCH INSTITUTE

OF CEYLON

THE TEA RESEARCH INSTITUTE,
St. Coombs, Talawakelle,
Ceylon.

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References

For 2. Plakidas, A. G., 1948, *Phytopathology*, **38,** 21.

read 2. Plakidas, A. G., 1952, *Phytopathology*, **42,** 16.

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Page 71—Title—*for* Report on a visit to North-East and South India
read Report on visits to North-East and South India

Page 88—Para 2, line 3—*for* Tea pectinic acid $\xrightarrow{\text{Pectin-methyl-esterase}}$ Pectinic acid + Methyl alcohol

read Tea pectinic acid $\xrightarrow{\text{Pectin-methyl-esterase}}$ Pectinic acid + Methyl alcohol

Page 102—Para 3, line 3—*for* meadow eelworm population was virtually
read meadow eelworm population in the soil was virtually

Page 105—Para 6, line 4—*for* crop *read* plant

Page 106—Reference—22, line 2—*for* Nematologica II
read Nematologica **2**

25, line 2—*for* Nematologica I
read Nematologica **1**

Page 124—Title of Table—line 1—*for* Gallinda Estate-Talgaswela
read Gallinda Estate, Talgaswela

line 2—*for* Three, year
read Three-year

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THE TEA QUARTERLY

VOLUME XXX JUNE/SEPTEMBER, 1959 PARTS II/III

EDITORIAL COMMENT

Tea in North-East and South India

In this issue of the *Tea Quarterly* a feature of interest to which the attention of our readers may be drawn is an account of a visit to the tea areas of North East and South India by the Technologist and Vegetative Propagation Officer of the Institute. Their report pinpoints certain aspects of tea cultivation and manufacture which are of particular applicability under local conditions. Following on the report on tea cultivation in the U.S.S.R. published in the last issue of the Journal, this review should serve to widen our knowledge of the various aspects of the cultivation of the crop in other parts of the world and furnish new ideas, some of which planters might try out for themselves to ascertain whether they are advantageous or feasible under their conditions.

Manuring of Tea

Of the technical articles, reference should particularly be made to the note by Dr. S. C. Pearce summarising his findings on the manurial experiments which have been carried out at St. Coombs and the other substations, in some cases over a period of several years. Dr. Pearce is the Head of the Statistics Division of the East Malling Research Station and recently came out to St. Coombs for a short period to undertake the statistical examination of the data of these experiments and to advise us on the future policy in regard to them and on field experiments in general. We acknowledge our indebtedness to him for the valuable contribution he has made on this aspect of the Institute's activities and thank the Director of the East Malling Research Station Dr. F. R. Tubbs, who is also our Scientific Adviser in the U.K., for having made available Dr. Pearce's services for this purpose.

In this connection, attention may be drawn to the report of the Agricultural Chemist in the T.R.I. Annual Report for 1958, which outlines certain trends shown by these experiments.

Pectic Substances in Tea

The paper by Mr. Ramaswamy on the pectic substances in tea throws some light on the possible relationship between this group of substances and the quality of tea. This work is, however, of a somewhat preliminary nature and further experimentation is needed to confirm the observations which he has reported.

The Control of Parasitic Eelworms in Tea

The comprehensive review by Dr. T. Visser on the prevalence and control of the parasitic eelworms in tea, marks a further advance in our knowledge of this important "pest" of tea. His paper is a fitting finale to the useful investigational work he has directed during his period as Acting Nematologist.

With the appointment of a full-time Nematologist in the person of Dr. M. T. Hutchinson, formerly of the Rutgers University, U.S.A., whose services have been made available to us through the good offices of the United States Operations Mission in the Island, work on the control of eelworms should continue to make rapid progress.

Lygus Bug

Notes on the *Lygus* bug by Mr. D. Calnaido should prove of interest to up-country planters in view of its fairly wide prevalence at higher elevations. Sporadic outbreaks appear to have occurred in 1956/57. The description of the pest and its life history, its habits and damage caused, and host plants are detailed in the article and methods of control suggested. Further work on the latter aspect would appear to be indicated.

Review of Tea Diseases

Readers interested in the history of tea diseases and their control in Ceylon would find the review by Dr. Mulder stimulating. It is apparent that there have been marked advances made with the study and control of certain important diseases, *e.g.* blister blight, in regard to which there has been continuity of effort and action. Other diseases such as *Phloem necrosis* have, no doubt for good reasons, not had a similar advantage.

Guatemala Grass and Soil Rehabilitation

The note by Mr. Tolhurst on the beneficial effect of Guatemala grass roots on soil rehabilitation offers confirmatory evidence of the work done by his predecessor, Dr. F. Haworth, in 1952*. It is noteworthy that Dr. Haworth's figure for the dry weight of roots in the first six inches of top soil is about the same, on the average, as is found by Mr. Tolhurst. Dr. Haworth further found that the roots went down to a depth of about 10 feet and contributed as much as 19 tons per acre of dry matter. Other grasses apparently have a similar beneficial effect on the top soil. In the light of these facts, the decision recently made by the Tea Subsidy Advisory Board to require that every old tea land which is to be replanted in future under the Tea Replanting Subsidy Scheme should be reconditioned for a minimum period of one year by planting out Guatemala grass, is indeed to be commended.

General

Our readers will also be interested in two notes, one by Mr. K. V. S. Krishna of Katary Estate, South India, on the effect of the application of plant-growth substances on clonal cuttings, and the other by Mr. B. Warusavitarne of Gallinda Estate, Talgaswela, on the successful adoption of a 3-year pruning cycle under conditions obtaining in the Galle District. Mr. Krishna's experiences are in accord with ours in respect of the effect of plant hormone solutions on naturally poor and good-rooting clones. Mr. Warusavitarne's trial confirms our findings at Ingiriya where a 3-year cycle was found to give next best results to the 18-month cycle. We welcome notes of this nature from practical planters.

*Observations on the Root System of Guatemala Grass on an Upland Tea Soil in Ceylon—F. Haworth; Trop. Agr., Vol. XXX, Nos. 4-6, April/June '53.

REPORT ON A VISIT TO NORTH-EAST AND SOUTH INDIA

F. H. Kehl and E. L. Keegel

One of the main objects of our visit was to familiarise ourselves with the latest developments in tea cultivation and manufacture, with particular reference to the progress made on vegetative propagation and development of factory machinery.

SUMMARY OF ITINERARY OF TOUR IN ASSAM

Monday, 29th September:	Met the Director. Went round laboratories. Visited experimental plots at Borbhetta.
Tuesday, 30th September:	Went to Borbhetta: saw breeding work. Discussions with Entomologist, Biochemists and Development Engineer. Visited two factories.
Wednesday, 1st October:	Visited large estate, saw V.P. plots and clonal seed bearers. Discussions with Dr. Wight and Senior Botanist. Visited two factories and spent rest of day in Development Branch.
Thursday, 2nd October:	Holiday. Saw Mechanical Plucking and seed bearers.
Friday, 3rd October:	Left Tocklai with Mr. P. N. Glover, Senior Advisory Officer to an estate in Doom Dooma. Inspected seed bearers (bearers) and visited one factory.
Saturday, 4th October:	Visited clonal seed bearers. Left for Calcutta.
Sunday, 5th October:	Left for Madras.

The extent under tea in North-East India is approximately 670,000 acres; the largest tea district is Assam consisting of over half the total acreage. Assam is divided into two districts, namely, the Brahamaputra Valley and Surma Valley.

Practically all the tea is on flat land. The soils are mainly alluvial and of recent origin and cannot be considered lateritic. The soils close to the Brahamaputra river are light and sandy and they become heavier towards the hills. In low lying areas, which are subject to water-logging, bogs are frequently formed resulting in the formation of a deep peaty soil that is locally termed bheel soil, which is very productive.

The elevation of the gardens ranges from 150 to 400 ft. above sea level.

The climatic conditions in Assam vary from district to district. It is generally warm and a striking feature of the climate is that during the rainy months, May, June, July and August there is no appreciable drop in either temperature or hours

of sunshine. Rainfall varies between 50 and 250 inches per annum; it is well distributed and droughts are rare. Assam has a definite summer and winter. During the latter period mists are very prevalent.

Nurseries

Large areas of jungle or scrub jungle are available in most gardens for opening of nurseries. Extensive nurseries are maintained in view of the large scale replanting being undertaken. As in most other field operations the work in a nursery is carried out to a set programme.

About the beginning of March seed of a suitable type of bush green manure, such as *Crotalaria anagyroides* or *Priotropis cystisoides*, is sown in single rows. Tephrosias are not used as they are susceptible to Red Rust which can cause a serious set-back to young tea plants.

The rows which are spaced 6 feet apart run North to South. These bush plants when grown provide natural shade to the young seedlings. Shade is sometimes provided by the use of tats.

Tea seeds are sown in November, about 8 to 10 inches apart. At these spacings, an acre of nursery takes about a maund of high jat Assam seed. From about the beginning of June the green manure plants are thinned out until about the end of August when all plants are removed.

Manuring

The nursery plants are manured six months after planting with a mixture consisting of 80 lb. Sulphate of Ammonia, 160 lb. ordinary Superphosphate and 160 lb. Muriate of Potash at the rate of 1½ oz. per 100 sq. ft. at fortnightly intervals.

Pests

Red spider is a serious pest in nurseries. Green flies can also cause some damage to nursery plants. The former can be controlled by two sprayings of 1 lb. Aramite 15 W and 5 lb. Thiovit or Spersul in 50 gallons of water. The latter is controlled by spraying DDT or Gammexane.

Removal of Plants

Trained men cut round each plant with a special type of spade and each plant is removed in a cylinder of soil about 15″ deep and 7 to 8″ in diameter. This method of planting is known as 'bheti' planting and is in effect similar to removal of plants by the Hersall method. The bhetis are taken carefully to the field in metal strips or in baskets. When the bhetis get broken in transit the plants are often discarded. All planting operations are usually carried out towards the end of the monsoon and occasionally about April.

Rehabilitation

Reconditioning of a nursery is considered an absolute necessity as much of the top soil is removed with the plants. A method of improving the soil is the addition of cattle manure at the rate of about 10 tons and leaving it under a leguminous bush cover for 2 to 3 years.

Infillings

Great care is taken when infilling, *i.e.* supplying vacancies. Large holes (about 2 feet) are cut and the soil is mixed with about 15 lb. of well rotted cattle manure. If cattle manure is not available, 8 oz. oilcake + 2 oz. ordinary Superphosphate are mixed with the soil: the side branches of the surrounding tea are cut to enable the young supply to get more sunlight. Large plants, not less than two years old are used as "infills." These are left unplucked for one or two years after which they are cut at a height of about 24" and the main stem decentered at 6–9" at the same time.

The method of infilling and the care and attention paid to infills are well worth adopting on estates in Ceylon.

Replanting

Replanting has been a regular feature in Assam for over ten years. Working on the assumption that the economic life of the light leaf Assam jats is about 40 years and that of the dark leaf Manipuri as 45 years, gardens replant between 2–2½ per cent of their total acreage annually.

Tea yielding less than 1,200 lb. is considered to be uneconomical. It is not always the lowest yielding fields that are uprooted but often those consisting of mixed jats on account of the poor quality tea they make.

Table 1 gives a comparison of the teas produced by mixed jats and selected Assam jats.

TABLE 1.—*Summary of* 36 *quality reports*

Quality	Mixed jats	Selected Assam jats
Poor ...	28	2
Good ...	5	14
Better ...	3	16
Best ...	0	4

An estate of nearly 400 acres extent, even though obtaining an average yield of over 1,850 lb. per acre, is uprooting old tea and has already replanted 30 acres with improved varieties during the past three years.

Forty-two acres of another estate that was replanted in 1952–1953 was brought into light plucking in 1955 and gave a yield of 583 lb. per acre. In 1956 the yield was 960 lb. and in 1957 1,100 lb. The growth of the tea was considered to be good.

In general we were very impressed with the appearance of the health of the plants as evidenced by the condition of the leaves and the absence of leaf diseases. The uniformity of the jat is very striking.

Uprooting Tea

As in Ceylon the most efficient method of uprooting tea is by a winch attached to a tractor. After the tea has been removed the area is levelled manually. This is followed by deep cultivation either with forks or by a rotary tiller attachment with tynes or rotary discs mounted behind a tractor.

Continuous monoculture is not recommended by the Tocklai Experimental Station as it is definitely not a good agricultural policy. Accordingly some form of rotation is advocated whereby tea does not succeed tea. The Institute has recommended that a leguminous bush crop be grown for a period of one year or preferably two years. The period of rehabilitation for fields yielding less than 750 lb. per acre is 3 years. Superphosphate is applied at the rate of 4 to 5 cwts. per acre at the time the green manure seeds are sown.

Shade trees, about 3 feet high, are planted about 8 months before the tea is put out. Initially the stand of trees is double that of the normal stand and as the trees grow larger they are gradually thinned out to provide the normal shade requirements.

Lining is not a problem on account of the lie of the land. The most popular spacing is 2 ft. by 5 ft. Holes 18″ × 18″, or trenches of the same dimensions are cut a few hours or a day before planting. Cattle manure or compost is applied at the rate of 10 lb. per hole together with 1 oz. of Superphosphate or 6 oz. of Sterameal. This application may be considered excessive in Ceylon, but it must be realised that any initial set-back to young plants is difficult to rectify at a later stage. The normal planting season is October to November.

Seeds of bush manures are sown between all rows about 4 to 6 months after the tea has been put out. Superphosphate is applied at the rate of 1 lb. to every 40 feet along with the seed. When the plants have grown to about 3 feet alternate rows are removed and plants in the rows left are thinned to a spacing of about 1 to 1½ feet. The sides of the green manure plants are cut to form a hedge.

Pruning

No thumbnail pruning is carried out. According to experiments carried out at the Tocklai Experimental Station any form of pruning of very young plants has resulted in restricting root growth. Any plant that grows to a height of over 2 ft. is tipped to about 20 inches but if plants are to be left in the nursery for over 2 years they are cut back to 16 inches during a dormant period.

In the field the plants are given their first prune a year after planting at a height of 18 inches. At the same time the main stem is decentered at 6–9 inches leaving all side branches. Plants with single stems are centered at about 6 inches. Heights of subsequent prunings which are carried out in September-October or January-February are given in Table 2.

TABLE 2.—*Heights of pruning and plucking*

Year in field	Pruning		Plucking
1st year ...	Cut-across	18″	30″
	December	6–9″	
2nd year ...	Prune	18″	30″
3rd year ...	Skiff	33″	36″
4th year ...	Prune	20″	30″
5th year ...	Prune	22″	30″

After the fifth year the plants are pruned every year about ½ an inch above the previous prune. Tipping is done at 8 inches above the pruning cut.

A medium prune of 22–26 inches is occasionally carried out in order to reduce the height of the plucking table. Tipping after the medium prune is done at 36

inches from ground level. The first pruning after a medium prune is done at 2 inches above the previous cut and thereafter the height is raised by $\frac{1}{2}$ an inch every year.

Plucking

Plucking commences about the middle of March and goes on until about the end of November. A bud and 2 leaves are removed up to the fish leaf every 7 to 8 days. Much attention is paid to maintain the plucking table flat, which is not a problem on account of the bushes being pruned annually and with the system of hard plucking that is adopted. As fields are flat in the Brahamaputra Valley the tea in bearing resembles a green carpet. The general condition of fields visited appeared to be very good indeed. The amount of cover in the older fields is excellent and above that of the average Ceylon estate.

Manuring

The first application of manure is given after a year. The mixture is 80 lb. Sulphate of ammonia (20.6% N), 160 lb. Superphosphate (16% P_2O) and 160 lb. Muriate of Potash (50% K_2O). In the early stages the rate of application is determined by the spread of the plant, the manure being dibbled or scuffled in. The rates vary from $\frac{3}{4}$ oz. to 10 oz. per plant.

Bushes in full bearing are given about 80 to 120 N between March and April. The manure is broadcast and followed by a light forking.

Shade

The gardens visited had very uniform stands of high shade trees, a striking feature being that they are not lopped. The most common trees are *Albizzia odoratissima* and *Albizzia stipulata* which are spaced according to the density of shade required. For light shade the spacing is 45′ × 45′, average at 40′ × 40′ and heavy at 30′ × 30′.

Planting is carried out in March-April when the plants are removed from the nursery in bhetis just as carefully as tea plants. Only healthy plants about 3 feet high are put out in clearings and larger plants 5 feet in height go into existing tea. Large holes 2 × 2 feet are cut and the soil is mixed with 20 to 30 lb. cattle manure and 1 lb. bone meal or Superphosphate. With such liberal applications of manure and care in planting it is not at all surprising that the Assam gardens do not have any difficulty in maintaining their shade.

Nurseries for growing shade are established in areas where the pH of the soil is not low. Well-rotted cattle manure is incorporated into the beds. About 5 lb. ordinary Superphosphate per 100 sq. yds. is forked in just before seed is sown. I have yet to see an estate in Ceylon paying such attention to shade tree nurseries.

Hard seeds soaked overnight are left in the sun to dry for a day before sowing. More difficult species require alternate soaking and drying two or three times.

Seed Bearers

The seed bearers that were visited were excellent. The trees are vigorous and the progeny of these bearers are surprisingly uniform, producing high yields and

good quality teas. These results have been obtained as a result of gardens selecting and isolating the more desirable types for the production of seed.

Spacing

The recommended spacing for the spreading types are 18′ × 18′ square or on the triangular system. The erect types are spaced at 15′ × 15′ square or on triangular systems.

Pruning

No form of pruning is carried out but low branches which interfere with cultivation or the collection of seed are removed.

Cultivation

Cultivation consists of a light hoeing after the collection of seed which takes place between October and December.

Manuring

For the first five years the mixture that is applied is similar to the one used in clearings. From the sixth year onwards a mixture consisting of 240 lb. Sulphate of Ammonia, 80 lb. Superphosphate and 80 lb. Muriate of Potash is used. The rates of application vary from 1 oz. to as much as 4 lb. per bearer.

Pests and Diseases

Tea seed bug (*Paecilocoris latus*) is a brightly coloured bug that can cause considerable damage to tea seed. It sucks the sap of the tea seed causing a "starring" effect on the cotyledons. This pest is controlled by hand collection.

Selection

Selection of mother bushes is based primarily on pubescence of the leaf, which is associated with quality. Such bushes are then examined for potential yield either by visual estimation or by a count made of flush shoots removed from an unit area of the plucking surface. At the same time the spreading habit of the bush is studied, bushes with a compact habit being preferred to trailing types. The former are considered to give higher yields than the latter which have a tendency to produce banji in the periphery.

The selected bushes are pruned, the frames are examined, and those with small wood and poor branch formation are rejected. The bushes retained are allowed to grow up when they are examined again. Plants with uniform growth, *i.e.* all shoots of about the same height, are selected and those with irregular growth are discarded. Bushes finally selected are plucked and miniature manufacture tests are carried out.

Nursery

As in Ceylon, soil that has been under grass is considered to be the best. Sandy and clayey soils are avoided.

Fig. 1.—Tea under shade for experimental purposes (Borbhetta).

Fig. 2.—V. P. nursery (Borbhetta).

Beds are made north to south. The soil is loosened to a depth of about a foot in January, followed by a very light forking early in February. The soil is then firmed by running a light precast concrete cylinder, as used for pipe culverts, over the prepared bed.

Shade is provided by bamboo lath frames which have proved to be very satisfactory. They are made of bamboo strips 1″ wide by ½″ thickness. The frames are placed on a 7″ high wall of either brick or bamboo.

Beds intended for planting in Spring (April-May) are kept shaded from the middle of March, by placing the lath frames on the side walls.

Beds for Autumn planting (September-October) are covered with a mulch and kept free of weeds. About the beginning of August all undecomposed mulch is removed and frames are placed by the middle of August.

In Assam the season at which cuttings are taken has an influence on rooting. Experiments have indicated that best results are obtained when cuttings are propagated towards the end of April and beginning of May and towards the end of September and beginning of October. The former period gives slightly better results than the latter. Very poor results are obtained in December, January and February.

Cuttings are generally taken and planted after sunset. The prepared cutting is inserted into the soil so that the leaf does not lie flat on the surface of the bed, but at an angle of about 30°.

When the majority of the cuttings have developed roots as well as shoots the tats are raised slightly on one side. To begin with the frames are raised so that there is complete shade by about 10 a.m. Gradually the period to which the cuttings are exposed to light is extended. Ultimately the frames are removed after about 4½ to 6 months.

Vegetative Propagation

Rooting trials in connection with the number of leaves retained on each cutting have shown that the cutting with one leaf is superior to one with two leaves which in turn is better than a cutting with 3 or more leaves.

An estate close to the Tocklai Experimental Station has made considerable progress in V.P. work. A large area has been replanted with 5 outstanding clones which are not yet in bearing. One of the selected clones has given a calculated yield of over 3,200 lb. of made tea in test plots. The policy of the estate has been to select their own clones rather than depend on selections made on estates in other regions. It is undoubtedly a very sound policy and the importance of estates making their own selections has often been stressed by Dr. W. Wight.

A count of the calcium oxalate crystals found in a transverse section of the leaf petiole of clones has shown that the number is fairly constant for each clone. The number of crystals is not altered by minor variations of cultural conditions. Shade is found to have an influence on the number of crystals. Numerous shade experiments are in progress at the moment and the results may prove that the shade requirements of each clone may vary to a great extent.

Though vegetative propagation was started about 20 years ago very few estates have made satisfactory progress. Recently, however, greater interest is being shown in V.P. work as evinced by the demand made for the Tocklai clones. Gardens are beginning to establish multiplication plots and a few Companies have appointed special officers in charge of propagation work.

Breeding

Tea breeding was started at the Tocklai Experimental Station about 1940. Although this work has not resulted in the production of high-yielding types of high quality, it is anticipated that outstanding seed will be made available to estates in the near future.

Breeding work is carried out as follows :

(1) **Mass selection.**—Seed of a recognised commercial jat are sown in a nursery and about 1 in 1,000 to 2,000 plants are selected as the future bearers. The basis on which selection in the nursery is carried out is as follows:—

(*a*) Pubescence.
(*b*) Vigour. (Thickness at the collar is an indication of vigour.)
(*c*) Good branch formation.

This method is not the ideal and is regarded as a temporary expedient. The progeny of such bearers will often be better than the best commercial seed that is available at the moment.

(2) **Polyclonal selection.**—Polyclonal seed gardens are established with about 8 to 10 desirable clones propagated vegetatively. Under the right conditions, this method can produce satisfactory results with fair rapidity. If the first generation seeds give the desired plants, then a full scale seed garden is laid out. This method is tried out in a few gardens.

(3) **Pedigree or bi-clonal selection.**—Selected pairs, propagated vegetatively, are mated artificially. Tocklai has made numerous matings of over 70 pairs and the progeny of some appear to be satisfactory. The yield of the progeny of a particular pair is well over 3 times that of commercial seed.

Mechanical Plucking

A mechanical harvester designed by the Resident Engineer is on trial at the experimental station. It is a much lighter machine than any of the Russian models. The cutter works on the same principle as an ordinary hair clipper, the moving blades being operated by an electric motor. The shoots are swept into the cutter by a four-bladed paddle and the cut shoots fall on a conveyer belt which takes the leaf to a bin. A selection bar about 1½ inches below the cutter prevents any tender flush being cut. The machine is able to harvest about 1,500 bushes per hour which is about 15 times as fast as a plucker.

Plucking is done on a 8–10 day round and sometimes extends to 15 days. The total number of plucks for the year is about 4 rounds less than that of hand plucking and there was no appreciable difference in yield between the hand and mechanically-plucked plots.

The standard of leaf harvested by this machine was not as selective as that plucked by hand but it was definitely superior to flush gathered by a tarpen cutter. Hardly any fragments or very coarse leaves were observed though the percentage of bud + 3 leaves was higher by about 10% in the leaf harvested by the machine.

A defect of the machine is that it does not remove all the tender banji. The difficulties of using a machine are the presence of shade trees and existing drains, and trouble may arise from ruts which the machine can cause. However, all these problems are being investigated by the Engineer who is very optimistic about the future of this machine, which is a splendid bit of engineering.

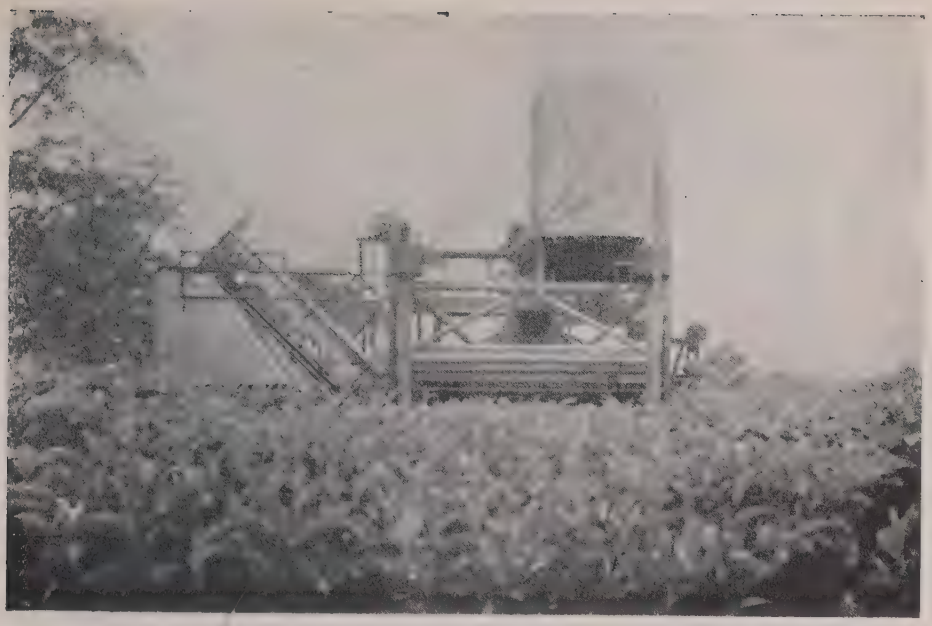

Fig. 3.—Experimental mechanical plucker in operation (Borbhetta).

Fig. 4.—Mechanically plucked leaf (Borbhetta).
(*Note the very little damage to the leaf*)

SUMMARY OF ITINERARY OF TOUR IN SOUTH INDIA

The general ground covered by our tour is indicated by the following summary:—

Monday, 6th October:	Left Madras for Coonoor *via* Coimbatore. Met Chief Scientific Officer, U.P.A.S.I. Visited one factory. Met Mr. Molyneux, Chairman of the Board.
Tuesday, 7th October:	Visited two estates (factories included).
Wednesday, 8th October:	Went to Devarshola. Visited two estates (factories included).
Thursday, 9th October:	Visited four estates and experimental plots at Devarshola.
Friday, 10th October:	Visited one estate (factory included). Left for Coonoor.
Saturday, 11th October:	Discussions with Chief Scientific Officer.
Sunday, 12th October:	Left Coonoor for Anamalais.
Monday, 13th October:	Visited two estates (factories included). Left Anamalais for Coimbatore.
Tuesday, 14th October:	Left Coimbatore for Madras.
Wednesday, 15th October:	At Madras.
Thursday, 16th October:	Left Madras for Colombo.

(Visits to estates from 6th October to 10th October were made in the company of the Chief Scientific Officer, U.P.A.S.I.)

There are approximately 165,000 acres of tea in South India, the main tea districts being Nilgiris, Anamalais, Nilgiri-Wynaad, High Range and Central Kerala.

As in Ceylon there are wide variations in climate in the different tea districts. Most tea plantations in South India get both monsoons, the rainfall varying from 55 to 280 inches. Some plantations are subject to long periods of dry weather.

The soils are generally red and yellow loams and are lateritic in origin. The pH ranges from 4.6 to about 5.6.

The temperature is relatively constant although it varies slightly in different regions due to elevation. The temperature in the Nilgiris and the High Range are lower than in other districts.

The methods of growing and cultivating in South India are very similar to those of Ceylon. Old tea is planted in lines up and down the hills, except on the more recent plantations which are on a modified contour system at a spacing of $5' \times 1\frac{3}{4}'$ or $5' \times 2'$.

Pruning cycles vary according to elevation. At low elevations they are from 2 to 3 years, at mid elevation between 3 and 4 and sometimes 5 years, and at high elevations they run to 6 or more years. There is at present a growing tendency for estates to extend their cycles.

Nursery

The preparation of nurseries does not differ from the methods adopted in Ceylon. Plants are transferred from the nursery into the field in baskets or as stumps.

Pruning

A low clean prune was a regular feature on estates in the past but in recent years a lighter system of pruning, in the form of a high cut across or a medium

clean prune has been generally adopted. The results obtained by the lighter prunes have been satisfactory. At low elevations rim lung pruning is carried out.

Tipping and Plucking

The method is almost the same as in Ceylon. Plucking is done to a level, but from the second year onwards, it is almost impossible to keep the table flat. The standard of plucking is bud + 2 with one leaf left over the fish leaf. The quality of leaf, however, of some of the estates visited does not compare favourably with that of Ceylon. One reason for coarse plucking is that estates are unable to keep to the normal 9 day rounds in rush periods.

Yields

Though the cycles are generally longer, yields are maintained. This may be due to the climate and the incredible richness of the soil. Table 3 gives an indication of yields of estates visited.

TABLE 3.—*Cycle yields*

Elevation	Field	1st Year	2nd Year	3rd Year	4th Year	5th Year
6,500	Good	428	1,310	1,301	1,333	1,613
6,500	Poor	427	1,446	993	1,141	1,114
6,000	—	600	1,477	1,396	1,347	1,675

Details of yields of another estate were not obtained but it was reported that one field was giving a yield of over 2,000 lb. in its 7th year.

Manuring

The recommendations of the Tea Research Institute of Ceylon are carried out except that some estates do not apply more than 30 lb. P_2O_5. No deep cultivation is undertaken except after tipping.

Weeding

There is a fine cover of weed growth including short grasses on some estates while others keep their fields free of all types of weeds.

Shade

Grevillea robusta is the most popular tree. They are grown as wind belts as well as for high shade and most estates pollard them regularly. The grevillea is not grown by itself but in conjunction with other trees. At elevations above 6,000′ it is grown interspersed with *Acacia decurrens*; below 6,000′ with (Dadaps) *Erythrina lithosperma*, *Gliricidia maculata*, *Albizzia falcata* or *A. stipulata*. As in North India great attention is paid to planting shade trees. Large holes are prepared and only healthy large plants are put out. They are often protected by baskets 4 to 5 feet high and about 15 to 18 inches in diameter.

Blister blight is prevalent at the higher elevations. Control methods are identical with ours.

Fig. 5.—General view of a tea garden in Assam with normal shade (Borbhetta).

Fig. 6.—Open withering shed in Assam.

Vegetative Propagation

Many estates, especially those subject to droughts, prefer using seed to V.P. plants. However, a few estates are making much progress especially in the Anamalais where the majority of the estates use V.P. plants for supplying vacancies.

An estate 6,000′–7,500′ elevation in the Nilgiri-Wynaad district has made much progress in V.P. work and has a clearing of 40 acres consisting of about 10 clones, some of which appear to be very promising. The growth made by some of the clones in 5–6 years, when they can be plucked lightly, is equivalent to that of 10–12 year old seedlings.

Another estate of about 3,000′ elevation which is subject to long droughts extending from 3–6 months' duration, has one outstanding clone that can be grown without any difficulty. This estate has about 60–80 acres of new clearings planted with clonal material.

We were highly impressed with the work carried out by these two estates.

MANUFACTURE

Manufacture in South India closely follows the lines adopted in Ceylon and there is nothing to report. As regards N.E. India, however, fundamental differences exist between the two countries both in climate and processing, and the teas themselves have little in common with those produced in Ceylon. For one thing they are not as well twisted and for another they possess a distinct character quite different from any tea made in Ceylon.

In order to get a clear insight into the purpose of the work being carried out at the Tocklai Experimental Station on the development of factory machinery it is necessary to consider the three following factors, since they have an important bearing, in our opinion, on the greater need for new machines in N.E. India:—

1. Climatic conditions.
2. Large amounts of leaf dealt with during rush seasons.
3. A system of manufacture which does not bring out the maximum colour and strengtn of the liquors from the leaf.

1. Climatic conditions

Temperatures in Assam are generally much higher than in most Ceylon estates and the humidity is so high during certain times of the year that rolling rooms, even with humidifying appliances, are too hot for rolling requirements. To keep down the rise in temperature of the leaf, rolling periods are shortened, pressure hardly applied and the rollers themselves are made to run much faster than in Ceylon. The difficulty of minimising the development of heat in the rollers has been a problem to Assam planters, and that is really why, as most people are aware of, light withers are taken in that part of the world.

A 75% wither, which is equivalent to nearly 65% moisture in the withered leaf, appears to be the norm, but this is not often achieved in Assam. Heavy rainy seasons make withering almost impossible and it is not an uncommon experience under these conditions to find that the leaf would not wither even in two or three days. In the absence of enclosed lofts with fans as in Ceylon, and lack of heating arrangements the percentage of wither may be anything. Under bad weather conditions leaf fed into the rollers is almost as green as when plucked from the bush.

Since the general practice from time immemorial has been to take light withers in Assam, it has not been considered economic to substitute the open leaf houses with lofts according to the Ceylon design. Today, with crops increasing and the difficulties being experienced with obtaining withers it is only natural that attention is being turned to the possibility of having a control over the process by the use of machines.

2. Rush crops

These are far in excess of anything experienced in Ceylon, and nearly two-thirds of the annual crop may be manufactured in 3 months of the year. Few factories have adequate withering space or machines to deal with the peak crops in a reasonable time. In the months of July, August and September the rush is so great that a large proportion of the leaf manufactured is literally green and all that matters is to have the withering sheds cleared and the equipment made available for the following day's intake of leaf.

For this type of manufacture, 'Kutcha' as it is called, the traditional roller is obviously quite unsuited and it is not hard to understand why Tocklai is taking trouble to produce a machine which aims at replacing the orthodox roller. This is not the only reason. It is also hoped by the development of a suitable machine which works on a different principle to that of the common roller to cut production costs and introduce a continuous method of manufacture.

3. System of manufacture

Owing to the lighter withers taken and higher atmospheric temperatures than those in Ceylon, leaf cannot be rolled hard without a considerable loss of juice and development of heat. In consequence the leaf receives little rolling—3 rolls at the most with a big bulk outturn of nearly 50% or more. From an inspection of a factory we visited the impression we had was that rolling was very much lighter than in our own low-country factories. No pressure was applied in the first rolls, which appears to be a general rule in Assam, the object being to conserve tip, which has a considerable value, so much so that hairiness of the leaf is one of the properties looked for in the selection of clones. It is perhaps a coincidence that pubescence goes with quality. Anyway if the claims made are true it is indeed an important discovery from the Assam viewpoint because both appearance and quality, two valuable assets in a tea, could be obtained together by merely selecting a clone on the basis of the amount of hairs its leaves possess.

As will be evident from the method of manufacture carried out not much of the leaf is ruptured to produce a good liquoring tea. Breakers and Myddleton stalk extractors are freely used to reduce the size of the teas. Harder withers and harder rolling, even if the former can be obtained by artificial means, are not favoured as it is believed that they would probably ruin the quality under the conditions of climate prevalent. Accordingly it is easy to explain the popularity of machines such as the C.T.C., which distorts the cells of the leaf to a much greater extent than the most efficient orthodox roller. In improving the liquoring properties by such means appearance of the tea naturally suffers but since the conventional teas turned out by Assam are as a rule flaky the trade has not discriminated against the new types.

The C.T.C. machine is not new. It was known in Ceylon 25 years ago but was not a complete success on the estates where it was tried due primarily to the fact that the style of Ceylon teas was radically altered. Its apparent success in Assam may be attributed to the following factors:—

(*a*) The appearance of the tea by Assam standards is not considered abnormal.

(*b*) The improvement in the liquor more than compensates for the poorer appearance.

(*c*) High standard of leaf. Gardens in India, which are reaping the benefits from switching over to C.T.C. manufacture, aim at 70% 2 leaves and a bud.

(*d*) Not more than 60% of the crop, comprising the best grades, is sold in London.

(*e*) Evenness of grading.

At the same time, however, there are many C.T.C. teas being produced which are of poor quality and appearance, partly caused by low standards of plucking and partly by incorrect methods. As the process accounts for a higher proportion of dust and off grades than conventional rolling it appears to be remunerative only if the plucking is fine. Thus C.T.C. manufacture is not the remedy, as most people think, for defects in a tea, and it may well be that certain gardens in N.E. India that adopted the C.T.C. process with the hope of improving their teas would revert to orthodox manufacture in the future. If so, the future for the rolling machines now being designed to take the place of conventional rollers will not be as bright as anticipated. In any case, orthodox machines will still have to be used to get the preliminary twist on the leaf. No machine designed yet at Tocklai has attained the standard set by the ordinary jacket and table. However, a description of the C.T.C. process will not be amiss as it will help to get a clearer understanding of the methods of approach by Tocklai to the modernization of tea manufacture.

C.T.C. Process.—The letters C.T.C. stand for Crushing, Tearing and Curling and as these words imply, the machine used is of the mangle-type. It consists of two cylinders specially designed with serrations on their surfaces in order to tear up the leaf and cause the rupturing of the cells. It of course does not curl the leaf as claimed. No juice is expressed by the roller, which is very similar in its action to that of the Clivemeare roller, where the process of rupturing is instantaneous. The leaf can be cut up to any size required according to the clearance between the two cylinders and the size of the perforations on their surfaces. The capacity of the machine is about 60 lb. of leaf per minute.

In brief, the process consists of first withering the leaf and then rolling it for about 30 minutes without pressure to obtain only a twist before being treated in the C.T.C. machine. All the leaf may be passed through twice, or the fines would be first separated over a green leaf sifter and only the bulk put into the C.T.C. machine. After this it is resifted and the coarse leaf may again be cut. The leaf is fermented and fired in the usual way. Despite withering and pre-rolling the resultant teas on account of the treatment received are flakier and smaller in size than conventionally rolled teas, and we do not think such a revolutionary process could be re-introduced into Ceylon with advantage, however useful the liquors might be.

Experiments on Mechanization

Since 1952 work has been going on at Tocklai to implement the plans of the Indian Tea Association for the modernization and rationalization of tea manufacture, the main objects in view being:

(1) Improvement of withers,
(2) Departure from conventional methods,
(3) Continuous manufacture.

It would appear from the results obtained to date (after a period of 6 years) that objectives 1 and 2 have been achieved but it will be some time before continuous manufacture as distinct from the present batch process will be a reality. During the course of the past few years many experiments have been carried out on various ideas on the mechanization of manufacture, and the results have eventually led to the development of the withering tunnel and the Rotorvane.

Up to the time of our visit only these two machines had reached a stage of commercial application, but observations were still being made and data being collected. Both are undergoing commercial trials in a few factories.

(1) **Withering tunnel.**—The prototype plant, the first of its kind in commercial operation, has to be experimented on further to work out the best method of operation. It is rectangular in design, and comprises 2 chambers, in which trolleys with trays of leaf are accommodated. These trays of wire-mesh are so pivoted that at the time of charging they are raised at an angle and then lowered one by one for spreading the leaf. When they are to be discharged the whole frame of trays is tilted downwards.

Operating temperature is 100°F or thereabouts and for the light withers taken the period of withering is not expected to exceed 2–3 hours. Under optimum conditions it is hoped to be able to charge the tunnel at the rate of about 2,000 lb. green leaf per hour.

In view of the limitations in withering leaf under existing conditions in N.E. India a controlled withering installation such as the tunnel may prove to be a valuable asset.

(2) **Rotorvane.**—This machine is cylindrical in shape, about 1′ in diameter and about 6′ long. At the feeding end a spiral moves the leaf along, which then passes through rotating vanes and over stationary projections situated along the length of the cylinder. These act like battens and break up the leaf. Internal pressure on the leaf is controlled at the discharge end by means of a hinged flap to which is attached an adjustable weight, the greater the resistance offered to the moving leaf the greater being the squeezing action.

It is claimed that one large Rotorvane is equivalent in capacity to 3 Senior rollers, and could keep a 6′ drier fully loaded.

The machine can be employed for either withered or rolled leaf, but the latter is preferred because of increased output. The leaf turned out has a pulpy appearance not unlike minced leaf but not so broken up. However, the machine appears to have given the desired results in the commercial trials undertaken.

(3) **Continuous manufacture.**—The Rotorvane just described is intended to be the rolling unit in the programme planned for continuous manufacture. As for withering, experiments are in hand for a continuous delivery of leaf to the Rotorvane, and thereafter employing the same principle for the fermentation process.

Clonal manufacture

Quality tests are being conducted at Tocklai on an extensive scale. Quality is being also examined in relation to chemical analysis. For this investigation selected clones are being systematically manufactured, their quality assessed by the tasters' findings and their chemical constituents determined.

Apart from this work, we were told that quite a number of tea gardens in Assam have their own miniature equipment. The impression we had was that serious notice was being taken of the future quality of Assam teas.

Conclusion

Summing up our impressions on what we have heard and seen during our brief visit to Tocklai and a few factories we think it would be detrimental to Ceylon interests to revolutionize the rolling process on the lines being followed at Tocklai. As for withering, neither the tunnel nor the envisaged continuous withering machine is a new idea. Versions of these were known 50 years ago and were presumably not followed up by engineering firms because of the satisfactory results obtained from a traditional withering loft. However, we cannot lose sight of the fact that sooner or later for economic reasons some form of withering machine may have to be employed in our own factories to cope with increasing crops.

It cannot be gainsaid that some very useful work has been and is being done on mechanization in tea manufacture. Tocklai is technically prepared to launch on a continuous system of manufacture in the future, but it remains to be seen whether a considerable saving in costs will be effected and whether the teas produced will meet the requirements of the trade. However revolutionary the methods employed may be, one thing is certain—withering will not be eliminated.

If Ceylon is to consider continuous manufacture we cannot get away from the fact that the traditional roller will have to be dispensed with. No machine yet devised or likely to be devised can produce a tea of the same style as that now being turned out by it. Whatever claims Tocklai may make about the traditional appearance of a tea being unaffected by the new machines, we would state that these claims cannot be substantiated in the case of Ceylon teas, for the simple reason that our standards are different from theirs. If we change the style of our teas they will cease to be true Ceylon types. Their character will also be altered and in consequence will not receive the recognition due to them from the trade, under present market conditions.

It is a matter of great satisfaction to us to state that the tour has been a most instructive as well as very pleasant one. At our meeting with the Director of the Tocklai Experimental Station and the Chief Scientific Officer of U.P.A.S.I., they did stress the importance of co-operation and the desirability of closer personal contact between officers of the different Tea Research Institutes. In the past, collaboration has to some extent been limited. We were in agreement that the various Institutes should do all they can to improve this situation. These visits are highly beneficial as officers do have the opportunity of meeting co-workers to discuss their results and programmes of work, etc.

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PECTIC SUBSTANCES IN CEYLON TEA

M. S. Ramaswamy

Introduction

An essential group of constituents of all plants is known by the general name of pectins or pectic substances. Commercially these substances are extracted on a large scale on account of their importance in the production of jams, jellies and canned fruit products. Even though pectic substances constitute from 4 to 8 per cent of the dry matter of tea leaf sufficient attention has not been paid to them, most of the investigations having been concentrated on other important constituents like polyphenols, caffeine, proteins, etc. However, occasional references have been made about the possible role of these substances in tea manufacture. Shaw (1) suggested that "the production of 'apple' smell in satisfactorily withered leaf may be ascribed to this transformation—(*i.e.* the demethylation of pectin during manufacture)—on analogy with the formation of the characteristic aromas produced during the ripening of fruits coincidental with pectic changes." Lamb (2) postulated that "characters such as stickiness of withered leaf and rolled leaf, often associated with good quality in Ceylon, maltiness of fired tea and the apple-like odour of well withered leaf may quite possibly be associated with pectin content," while Roberts (3) mentioned that "changes in the pectins are probable but these have been but little investigated."

Shaw suggested a technological differentiation between two kinds of pectic substances. They are the 'infusion' type (water soluble) and the 'texture' type (water insoluble); the former is present mostly in the tender portions of the flush while the latter occurs in older leaves and stalk. While the 'infusion' type imparts certain liquoring characteristics to tea, the 'texture' type helps in the keeping properties of made tea and also in protecting tea polyphenols by reacting first with heavy metals which would otherwise affect the polyphenols. Following this work in South India, Lamb carried out the analysis of Ceylon green leaf for pectic substances but he made no distinction between the various fractions. His results showed wide variations in pectic contents in samples of leaf of varying ages. It has recently been shown that the pectic content of tea leaf from shaded areas is slightly less than that found from unshaded areas (5).

Nomenclature of pectic substances

Pectic substances are complex colloidal carbohydrate derivatives containing a large proportion of anhydro-galacturonic acid residues which are probably linked in a chain structure. The carboxyl groups of these units may be partly esterified by methyl groups and partly or completely neutralized by one or more bases. According to the most recent nomenclature (4), the following terms are used for various fractions of pectic substances:—

Protopectin — Precursor of pectic substances, insoluble in water.

Pectinic acid — Colloidal galacturonic acids containing appreciable proportions of methyl ester groups, soluble in water. (Water soluble tea pectins fall into this group).

Pectin — Composition same as pectinic acids but capable of forming jelly with sugar and acid The commercial products of pectin belong to this group. The ideal pectin (completely esterified with methyl alcohol) contains 16.3 per cent methoxyl groups, but so far such a product has not been isolated from any vegetable source.

Pectic acid — Pectic substances free from methyl ester groups. This group is possibly present in the protopectin in combination with bivalent metals like calcium and magnesium. It combines readily with heavy metals to form a precipitate. In the determination of pectic substances in tea (for which 0.5% aqueous ammonium oxalate is used as solvent) this group along with the water soluble fraction is estimated as total pectin content.

Protopectin in tea

Protopectin is probably found in the middle lamella and primary cell membrane of the leaf. Being insoluble in water it is not likely to play an important role in the manufacture of tea. However, during withering part of it may be broken down to pectinic acid. An increase in the pectinic acid content is found to occur during withering—see table below:

St. Coombs Estate leaf

	Water soluble pectin (% dry matter)	Water insoluble pectin (% dry matter)
Green leaf ...	3.62	0.92
Withered leaf ...	4.24	1.60
Fermented leaf ...	3.84	1.60

Pectinic acid in tea

The pectinic acids from different plant materials are heterogeneous containing varying proportions of methoxyl groups. In Ceylon tea leaf, pectinic acid appears to have a fairly constant composition containing 4 to 5 per cent methyl alcohol. The composition of fractions of pectic substances from green leaf prepared by two different methods is shown below. In one experiment (I) the fractions were prepared directly from dried green leaf while in the other (II) the leaf pigments were removed completely with acetone prior to fractionation.

Fraction of Pectic substances:	*Experiment I*		*Experiment II*	
	(*a*)	(*b*)	(*a*)	(*b*)
(1) Soluble in water ...	51.6	3.84**	58.5	4.35*
(2) Soluble in 0.5% oxalic acid	45.5	3.39*	61.0	4.54*
(3) Soluble in 0.5% ammonium oxalate ...	54.8	4.08*	62.6	4.66*

A comparison between citrus pectin (B.D.H. 100 grade) and a highly purified preparation of tea pectinic acid from a single clone (clone No. 9) showed that the latter contained a higher percentage of methoxyl groups than the former.

(a) Methyl alcohol expressed as mgs. in 100 gms. dry leaf
(b) Methyl alcohol expressed as % pectinic acid
** Actual determination. *Calculated.

	Methyl alcohol (Moisture and ash-free basis)
B.D.H. Citrus pectin (100 grade) ...	4.28%
Tea pectinic acid from clone No. 9 ...	5.06%

Role of pectinic acids in tea manufacture

The biochemical changes that occur to the pectinic acids in tea during rolling and fermentation have been studied in detail in this laboratory and the results published from time to time (5–8). The presence and role of an esterase (enzyme) controlling these reactions was reported for the first time.

The general course of reaction of this enzyme-substrate system occurring during rolling and fermentation may be represented as follows:—

$$\text{Tea pectinic acid} \xrightarrow{\text{Pectin-methyl-esterase}} \text{Pectinic acid} + \text{Methyl alcohol}$$

The optimum conditions for this reaction are a pH of 6.8 and a temperature of 45°C. The reaction commences as soon as the leaf is rolled and continues during the period of fermentation. During firing, however, the enzyme is completely inactivated and the reaction is thus arrested. This reaction does not occur if the leaf is steamed prior to its rolling and fermentation. The enzymic nature of the production of methyl alcohol during fermentation has been clearly demonstrated.

	Methyl alcohol produced during fermentation (Results expressed as mgs. methyl alcohol from 100 gms. dry leaf).	
	Experiment 1	*Experiment* 2
Green leaf withered, minced and fermented for 2½ hours	39.4	26.8
Green leaf steamed, withered, minced and fermented for 2½ hours	0	0

Methyl alcohol production during fermentation has also been demonstrated in leaf subjected to different types of rolling treatment in the factory; quantities of methyl alcohol varying between 28 and 37 mgs. per 100 gms. dry leaf have been collected during the 4 hour period of fermentation. A combined collection of this methyl alcohol along with other volatile constituents from fermenting leaf (small scale collections made by sweeping the volatiles by a current of air, absorbing in water and extracting with ether) gave a minute quantity of a yellow crystalline material with a very strong and pleasant odour of tea. The quantity of the crystalline material collected was, however, insufficient for identification.

Part of the methyl alcohol formed during fermentation is possibly reacted upon by organic acids or other constituents to form non-volatile esters. Thus increase in this hydrolysable methyl alcohol was found to occur in the fermented leaf when compared with that present in withered leaf. In these experiments free volatile matter was removed by steam distillation before hydrolysis.

	Hydrolysable methyl alcohol expressed as mgs. in 100 gms. dry leaf	
	Experiment 1	*Experiment* 2
Withered leaf	146	215
Fermented leaf (4 hours) ...	179	242

During fermentation, the pectin-pectinmethyl esterase enzyme system does not exert its optimum degree of reaction since the temperature and pH of the

fermenting leaf are very much lower than the optimum conditions necessary for it. The temperature of the leaf coming out of the rollers is about 32°C while that of fermenting leaf is about 27°C. The acidity of the leaf also increases due to the formation of pectic acid, the pH changing from 5.66 in withered leaf to 5.10 in dhool fermented for 4½ hours.

One of the properties of pectic acid is its ability to form a gel under acidic conditions. Pectic acid formed during fermentation is therefore likely to form a gel under the acidic conditions of the fermenting leaf and remain as a thin layer over its surface. This would enable the leaf to retain its twisted appearance. The thin film of the gel may impede the easy diffusion of oxygen to the tea polyphenols and also act as an antioxidant or preservative to the made tea. The inhibition of the oxidation of tea polyphenols has been demonstrated by a number of experiments both with minced leaf (laboratory conditions) and factory rolled leaf. In these experiments minced leaf and rolled leaf were deprived of oxygen for varying periods so that only the reaction between tea pectin and pectin methyl esterase enzyme could take place. The material was then allowed to ferment under normal conditions in the presence of air. During the period of one hour's fermentation, treated samples showed a definite loss of capacity to absorb oxygen. Depending upon the conditions of experimentation, this loss was found to vary from 2 to 12% in the factory rolled leaf and 6 to 48% in the minced leaf. The lower figures obtained in the factory rolled leaf were due to pre-fermentation that occurred before the leaf could be brought to the laboratory and in minced leaf to oxygen (air) which was already held up in the leaf and reacted before it could be evacuated. The higher figures were obtained when the air was continuously swept off by a current of carbon dioxide during evacuation. In another experiment where green leaf was treated with a commercial grade of pectin (2.6%), the loss in oxygen absorption capacity was found to be nearly 40%.

Further proof of the action of pectic acid on the oxidation of tea polyphenols was adduced under practical conditions using the experimental machinery in the factory. Freshly harvested clonal leaf from St. Coombs covered with dew was dusted with different quantities of a commercial pectin, and manufactured under normal conditions. The made tea samples were sent to professional tasters in Colombo. The results are shown below:

Experimental details.	Tasters' report on liquors.
1st Manufacture: Fermentation for 4 hours.	
Control	... Great strength
Green leaf treated with 1.3% pectin	... Light and green
,, ,, 2.6% ,,	... Very thin and green
2nd Manufacture: Fermentation for 3 hours.	
Control	... Good colour and strength
Green leaf treated with 1.5% pectin	... Little greenish
,, ,, 3.0% ,,	... Very green
3rd Manufacture: Fermentation for 2 hours.	
Control	... Good colour and strength
Green leaf treated with 1.5% pectin	... Greenish
,, ,, 3.0% ,,	... Very green

The pectic acid formed was also found to protect the fermenting leaf from too rapid condensation of the oxidised polyphenols. The degree of condensation may be judged from the analysis of made tea for its ethyl acetate soluble fraction. The lower the percentage of this fraction the higher is the degree of condensation (9).

	% dry matter soluble in ethyl acetate	
	Experiment 1	*Experiment* 2
Control	11.26	7.75
Rolled or minced leaf held in absence of oxygen before fermentation ...	12.49	10.21

The property of gel formation was demonstrated in green leaf collected from the factory bulk as well as in a clone which was found to have a very high pectin-methyl esterase enzyme activity. When the leaf was rapidly comminuted with water and incubated at 50°C, the whole mass set into a firm gel in 4 hours. The surface of this mass assumed the characteristic coppery red colour during this period on account of its access to air. The rest of the mass remained perfectly green. Evidently the diffusion of oxygen to the lower layers of the mass was prevented by the gel.

It is probably fortunate that conditions in the leaf during fermentation are not optimum for the activity of the pectin-methyl esterase enzyme; otherwise fermentation might be inhibited before a satisfactory degree of oxidation of the catechins could be achieved. Undoubtedly there is a balance between the activity of the polyphenol oxidase and the rate of formation of pectic acid.

Variation in the pectinic acid content of clonal leaf

The study of the variations in the pectinic acid content of teas is more important than any other fraction on account of its role during fermentation. The usual method of its determination as calcium pectate (Carre and Haynes) (10) was found to be long and tedious. A rapid method was therefore evolved for a rough estimation of pectinic acid. In this method the leaf samples were freed from steam volatile matter, hydrolysed with mild alkali and the methyl alcohol formed was distilled. For oxidation and determination of the methyl alcohol in the distillate, the method of Walkley and Black (11) was adopted after a slight modification. Though the results were found to be quite reliable, the final values obtained were found to give 90% recovery on account of interference from volatile matter from constituents of leaf other than pectinic acid. For purposes of converting methyl alcohol into pectinic acid, it was assumed that tea pectinic acid contained 4.5 per cent methyl alcohol.

A summary of results of recent research on the variations in the pectinic acid content of clonal leaf from St. Coombs under different conditions is indicated below:

1. There is a progressive increase in the pectinic acid content of the flush fractions from bud to 3rd leaf while the stalk contains as much as the 2nd leaf. When the total pectic substances of the flush fractions are taken into account, the pectinic acid fraction appears to show similar increase except in stalk which contains the least percentage.

	Pectinic acid (% dry leaf)	Total pectic substances (9) (% dry leaf)	Pectinic acid as % total pectic substances
Bud ...	1.76	4.9	35.9
1st Leaf ...	2.31	6.1	37.9
2nd Leaf ...	2.38	4.7	50.6
3rd Leaf ...	2.64	5.0	52.8
Stalk ...	2.38	7.6	31.3

2. There is an increase in the pectinic acid content of flush as the age from pruning increases from 9 to 21 months, while it falls to a lower level in bushes 33 months old from pruning.

Age from pruning	Pectinic acid % dry leaf
9 months	1.44
21 months	1.49
33 months	1.02

3. A comparison between high and low quality clonal flush showed that the pectinic acid content of high quality clones was higher than that in poor quality clones.

Sampling period	Clones above average quality Clone No.	Pectinic acid % dry leaf	Clones below average quality Clone No.	Pectinic acid % dry leaf
November, 1957	1294	1.60	407	1.22
February, 1958	2023	1.49	1114	1.02

4. The pectinic acid content of flush appears to increase during dry weather, particularly when the variations in the day and night temperatures are extreme.

Quality of the clones	Difference between maximum and minimum temperature on the previous day to sampling	Pectinic acid % dry leaf
Above average	16°F	1.44
	8°F	0.47
Below average	16°F	1.38
	14°F	1.22

It has been shown that protopectin may be broken down to pectinic acid during withering. But further breakdown of pectinic acid is unlikely since measurable quantities of methyl alcohol were not found to occur during this stage.

Pectic acid in tea

It is not improbable that pectic acid formed during fermentation combines with heavy metals to form the respective insoluble pectates. The water soluble fraction in made tea would thus be less than that in withered leaf. Shaw's results on the pectin content of South Indian teas show a loss of about 17 per cent of the water soluble fraction (expressed as calcium pectate) during manufacture, evidently due to de-methylation of pectinic acid and subsequent combination of pectic acid with metallic ions. Experiments in this laboratory have shown that at least 16 per cent of the methyl alcohol of pectinic acid is hydrolysed and lost to the atmosphere during fermentation. Even though these two results are not directly comparable, they indicate the possibility of pectic acids being rendered insoluble during fermentation.

Summary

1. A partial breakdown of protopectin appears to take place during withering.

2. The methyl alcohol content of tea pectinic acid varies from 4–5 per cent.

3. Pectinic acids are broken down to pectic acid and methyl alcohol during fermentation. The pectic acid formed impedes the oxidation of tea polyphenols and possibly the condensation of oxidised polyphenols.

4. There appears to be some relationship between quality and the pectinic acid content of teas. The high quality teas produced during dry weather conditions may probably be related to the presence of a high percentage of this fraction.

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A RECENT STUDY OF THE RESULTS OF SOME CEYLON TEA FERTILIZER TRIALS

S. C. Pearce

From its early days the T.R.I. has conducted experiments on the fertilization of tea. Today the importance of this subject can hardly be in doubt and I have recently visited Ceylon to sift through the accumulated evidence from several experiments, two of them over 24 years old.

In most of these trials the crops did not reach present-day levels. Plainly it would be a mistake to infer too much from these results about the fertilization of really heavy crops.

Nitrogen

One result that stands out is the paramount importance of nitrogen. When the T.R.I. started, its use was suspect, but planters today are aware of the "eight-pound ratio," and often use the "ten-pound ratio" instead, but it may be questioned whether even this is enough. Eden (1949) showed that 100 lb. of made tea takes 6.38 lb. of nitrogen from the soil. Losses must be large, so 8 lb. by way of replacement does not seem a lot. Certainly there is evidence that it could well be increased. Thus on Field 3 at St. Coombs during the third, fourth and fifth pruning cycles the crop averaged 695 lb. per acre per year. Using the "eight-pound ratio" this means that about 56 lb. of nitrogen per acre should have been applied each year. Actually the experiment tested 40, 60 and 80 lb., and this resulted in 625 lb. of tea from the lowest level, 691 lb. from the middle and 771 lb. from the highest. In fact the bushes were able to make good use of 80 lb. of nitrogen. What is more, the response is not falling off, the increase of crop from the second increment of nitrogen being quite as big as that from the first. Here then is an instance when more fertilizer could usefully have been given. Much the same thing happened in the sixth, seventh, eighth and ninth cycles. Over this period the crop each year averaged 642 lb. per acre, so the amount of nitrogen called for by the "eight-pound ratio" would have been rather less than before. Even using the "ten-pound ratio" about 65 lb. per acre would have been the recommended dressing. The crops for the low, medium and high dressings were respectively 570 lb., 636 lb. and 719 lb. per acre. Once again it was worth while to use more nitrogen than the recommendation, and once again the response showed no sign of falling off as higher levels were reached.

This does not always happen. Thus, at Endane in the low country no response at all was found from nitrogen during the first two cycles, amounting in all to three years. Nevertheless, the trial was a very sensitive one, well able to detect quite small differences, so there are circumstances in which nitrogen does no immediate good. However, in this trial the lowest of the three levels was 80 lb. per acre, and this is quite high. It is unlikely, though, that the area can continue to crop at its present level without reaching the point when further nitrogen will be needed.*

**I am told that later results are now available, and these suggest that high nitrogen (160 lb. per acre) may even be reducing crop as compared mith 80 lb. per acre. This result, if confirmed, is surprising, but it serves as a warning against the uncritical use of really high dressings of nitrogen. S. C. P.*

In general, it appears that the "eight-pound ratio" is rather low, but nitrogen should not just be piled on. A "ten-pound ratio" is probably about right.

Phosphate

The story with phosphate is very different. Here we can easily give too much. For example, in the trial at Passara applications of 30 lb. per acre as superphosphate had to be given up because of the harm they were doing. Thus in the fourth and fifth pruning cycles the bushes without phosphate gave 663 lb. per acre per year, but those with it gave only 600 lb.

Something similar happened on Field 3 in the trial already mentioned. Here in the third, fourth and fifth cycles, the trial compared no phosphatic fertilizer with applications of 30 and 60 lb. per acre as superphosphate. The crops per acre were respectively 638 lb., 713 lb. and 725 lb. for these three levels of phosphate. The highest application had done no harm, but neither had it done much good. For the next four cycles the figures were 599 lb., 673 lb. and 653 lb. Here it might seem the largest dose had done harm. Possibly the decrease in crop is just chance, but the result will not encourage anyone to spend money on more phosphate than was given by the middle application.

How do these results fit in with current manurial practice? Using T.R.I. 500 at the "eight-pound ratio," 3.8 lb. of P_2O_5 is given for each 100 lb. of crop. Consequently, at Passara the recommended application would be 23 lb., or 28 lb. if expansion were attempted, and this latter figure certainly is too much. On Field 3, however, the recommended dressings of phosphate would be about right, though they should certainly not be increased. In fact, if more nitrogen is to be given, we should not increase the phosphate as well.

It appears that 100 lb. of crop removes 1.55 lb. of P_2O_5 from the soil (Eden, 1949). Using fertilizers at present rates, there may be a build-up of phosphate in the soil over the years, because unlike nitrogen it is not immobilised by bacteria. At first this may not matter, but eventually more will be supplied than the plants require. It is not known if this will do harm, but it is quite possible that it will.

The question arises here whether the form of phosphate is important. The trials at Passara and on Field 3 used superphosphate, but rock phosphate is more usual in commerce. Certainly superphosphate leads to a build-up of calcium in the leaves, a result clearly established by chemical analyses carried out in 1952 on samples from Field 3. However, this may happen with rock phosphate also, and it is not certain that a reasonable excess of calcium is harmful. Altogether this question is very open, and much more needs to be known.

It may be noted that the best level of phosphate does not appear to have anything to do with the amount of nitrogen given. That being so, there is no need to tie the application of phosphate to that of nitrogen as is done with a standard fertilizer mixture. It would certainly be wise to ensure a good supply of phosphate for a start, but as crops begin to rise there seems little point in increasing the applications in proportion. It should then be good enough to put back about 3 lb. of P_2O_5 for each 100 lb. of crop.

Potash

The evidence is that present applications are about right. For a long time potash may appear to have little effect, but if too little is given the consequences can become serious in the extreme. On no account, therefore, should it be ignored. A 100 lb. of crop takes 3.47 lb. of oxide of potash out of the soil (Eden, 1949); T.R.I. 500 at the "eight-pound ratio" puts 4.7 lb. back. This seems a sound practice.

A need for balance

The fertilization of a plant can never be considered only in terms of NPK, though these are the most important elements. The early workers at the T.R.I. rightly started with these three, but it is generally accepted that there are others that can matter. For example, Tolhurst (1956) has pointed out the need for magnesium. These minor elements need to be taken into account when deciding the form of fertilizer to be used, because most are given incidentally in substances chosen for their content of N, P, or K.

Among the major elements also a balance must be preserved. Anything taken out of the soil must be replaced or impoverishment will result, so over a period fertilization must be more or less on a replacement basis. It would therefore be a mistake to give nitrogen alone, even though for the moment phosphate and potash appeared to be sufficient.

However, this does not mean always giving the three major elements in the same proportion. For phosphate at least it appears that there is a best level, neither too low nor too high. A constant mixture can well give too much phosphate when crops are high, or else give too little when crops are low.

Finally, it should be emphasized that this paper is concerned with the results available to date from four trials. These need to be considered along with any other evidence that may be available, and the whole seen in perspective. In particular, special local conditions can call for special measures.

Acknowledgments

I have benefited greatly from conversations with Dr. T. Eden and Mr. J. A. H. Tolhurst, both of whom have had long experience of these matters.

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OBSERVATIONS ON THE PREVALENCE AND CONTROL OF PARASITIC EELWORMS IN TEA

T. Visser

1. Introduction

The problem of eelworms in tea nurseries and tea plantations of Ceylon is not a new one, as its discovery dates back to the inception of the Institute. In 1928 Stuart Light (24) drew attention to the destructive powers of the root-knot eelworm in tea nurseries. This eelworm, then called *Heterodera radicicola*, later named *H. marioni* and now known under the name *Meloidogyne javanica*, was also found responsible (7) for the poor growth and dying of dadaps, *Erythrina leucosperma*. In 1937 (8) it was discovered that the degeneration of *Tephrosia vogelii* was also due to attack by this eelworm. With respect to its spread it can be said that it can be found in many tea soils.

Mature tea was not found to be very attractive to this particular species, but Loos (17) ascertained in 1951 that a member of the same family, *viz. M. brevicauda*, was able to do severe damage to tea. So far, however, this eelworm is known to be present in an acute form on a few estates only.

The position is different with regard to the meadow eelworm which was discovered by GADD in 1939 (10, 11) and found to attack both young and mature tea. This eelworm was at that time known under the name *Anguillulina pratensis* and is now called *Pratylenchus coffeae*[1]. Its spread in tea appears to be much more extensive than that of *M. brevicauda*[2], for Loos reported in 1951 (17) that the presence of meadow eelworm had been ascertained on 50 estates, mostly at up-country elevations. At present meadow eelworm is known to be prevalent on many more estates.

It is usually noted in fields planted before 1900; the build up of the parasitic eelworm population to harmful levels in a monoculture of such long standing can be no matter for surprise. Its effect may have been aggravated by the gradual weakening of the bush with increasing age as well as unsatisfactory bush and soil management in the past. The preponderance of eelworm infestation at up-country elevations may also be partly explained by the fact that the tea in many estates was preceded by coffee. The latter crop is known to be susceptible to the same eelworm as tea (*P. coffea*).

Our information as regards its occurrence in the low- and mid-country is limited to a few estates only. A comprehensive survey may reveal a different situation, though possibly the infestation may be really less due to different conditions of soil and climate and because the tea is on the whole considerably younger.

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[2] *Identification by: SHER, S.A. and M. W. ALLEN; Un. Cal. Zool.* **57**, 1953:441-470.

2. Effect on yield

As stated above, meadow eelworm has been found to be present on a large number of estates, though this does not mean that it can be labelled a pest on all these estates. According to present day information meadow eelworm occurs as a pest in an acute form in certain fields on a dozen estates or so only, while other estates where meadow eelworm is also present do not seem to suffer (as yet).

The general pattern of meadow eelworm infestation in mature tea is similar to that observed in other crops. It starts off in a certain field or fields as small patches of bushes or single infected bushes here and there. The patches gradually expand resulting in the general infestation of large areas.

The visual symptoms of infestation are not specific. Severe infestation initially results in the tea bush, often the weaker ones, becoming dormant, usually during drought periods and/or in the latter part of the pruning cycle. This is often followed or accompanied by yellowing of the leaves and defoliation in part or whole in the later stages. Subsequent pruning of such a bush leads usually to its death or to such poor recovery that the bush can be considered useless from an economical point of view. This process, though slow where the whole field is concerned, may be fairly rapid with respect to the individual bush. The low yield of a heavily infested field at a given time is largely due to the large number of vacancies which have occurred over the years, the majority of the remaining bushes appearing to yield normally.

In 1939 Gadd (11) gave an example demonstrating the severity of this pest in terms of loss of crop. In table 1 we have presented some additional yield data of fields known to be infested in comparison with those of fields lightly or not infested, from estates situated in different districts.

The general picture presented by the data given in this table is that the annual yields of comparable fields started to diverge at some time in the past and progressively more so with the years. That is to say, at some stage the yield of the eelworm infested field commenced to decrease as compared with a non-infested field, which was otherwise comparable in treatment, age, site, etc.

On estate I, infestation in an acute form dates back from 1942, on estate II from 1931, while on estates III, IV and V the pest became acute only fairly recently. It is also worthy of note that in some infested fields the downward trend appears to have been checked, undoubtedly due to improved soil and bush management. Nevertheless, the loss in crop is still real, as the yield of the non-infested fields increased in the meanwhile. The loss amounted to about 250 lb. tea/acre/year in all instances.

Where *e.g.* on estates I and II the yields of the so-called non-infested fields remained more or less constant over the last 10 to 15 years, it may be suspected that in these fields too the infestation has been building up, but that its effect has been masked by the introduction of better agricultural practices.

TABLE 1.—*The effect of spreading meadow eelworm (Pratylenchus coffeae) infestation over the course of years on the yield per acre (lb. made tea) on differently situated estates*

I. Mooloya. Elevation: 5,000–5,800 ft.

Yield of period	N. Inf. 24 ac.	Inf. 52 ac.	Loss of crop	N. Inf. 16½ ac. 1896†	Inf. 32 ac. 1899*	Loss of crop
1933—1942	650	630	3%	700	650	7%
1943—1947	840	570	32%	850	700	17%
1948—1952	800	560	30%	830	530	38%
1953—1957	780	390	50%	880	510	42%
Avg./acre since 1943	800	510	37% (290 lb.)	850	580	32% (270 lb.)

II. Rutland. Elevation: 3,300–3,500 ft.

Yield of period	N. Inf. 64 ac. 1888*	Inf. 38 ac. 1891*	Loss of crop
1924/25 — 1930/31	690	950	— 37%
1931/32 — 1937/38	750	490	+ 35%
1938/39 — 1944/45	680	160	+ 76%
1945/46 — 1951/52	660	250	+ 62%
1952/53 — 1957/58	760	410	+ 46%
Avg./acre since 1924	710	450	37% (260 lb.)

III. Ellamulle. Elevation: 4,000 ft.

Yield of period	N. Inf. 32 ac. 1900*	Inf. 27 ac. 1900*	Loss of crop
1945 — 1951	550	540	2%
1952 — 1954	750	560	28%
1955 — 1957	920	610	24%
Avg./acre since 1952	840	580	31% (260 lb.)

IV. Dambatenne. 4,600–5,800 ft. **V. Wootton.** 4,100–4,400 ft.

Yield of period	N. Inf. 31 ac. 1894*	Inf. 34 ac. 1894*	Loss of crop	N. Inf. 15 ac. 1895*	Inf. 43 ac. 1890*	Loss of crop
1945—1951	760	740	3%	630	550	13%
1952—1954	1000	680	32%	830	720	13%
1955—1957	900	680	24%	1180	810	31%
Avg./acre since 1952	950	680	29% (270 lb.)	1000	770	23% (230 lb.)

N.B.- Loss of crop is expressed in percentages of yield from not infested fields; N. Inf.=not or lightly infested; Inf.=infested; ac.=acres; *approximate year of planting.

The figures given illustrate that it may take a long time before the infestation manifests itself as a pest, but once it does the yields drop very markedly mainly due to the loss of bushes.

3. The effect of organic matter on eelworms

With respect to the application of organic matter, it would seem that it may have a direct effect on the incidence of eelworms, apart from its beneficial effect on the soil and the plant.

Lindford *et al* (16) ascertained that the incorporation of large amounts of green material (of the order of 50 tons/acre) significantly reduced the number of *H. marioni* galls on roots of indicator cowpeas. Similarly Oostenbrink (20)

found in field experiments that the application of stable manure (10 tons/acre) markedly reduced the *Pratylenchus* and *Meloidogyne* populations both in the soil and in the roots of agricultural crops grown on the treated soil. Likewise Van Der Laan (25) in pot experiments with potatoes ascertained that the addition of stable manure or compost suppressed the development of the potato eelworm in the roots.

With respect to the effect of manure on eelworm in tea soils a preliminary trial was laid out on an area fairly heavily infested with meadow eelworm. This area was divided into 2-acre blocks, respectively (*a*) kept fallow, (*b*) fallow, treated with a single application of pig manure (20 tons/acre) and (*c*) planted with Guatemala grass. From subsequent monthly sampling on the degree of infestation it appeared that the *Pratylenchus* population gradually decreased in all treatments. The number of eelworms per 100 g. soil (6 samples/time) had become almost nil after 8 months in the grass soil and after 13 and 14 months in the fallow and manured soil respectively.

Thus it would appear that the planting of Guatemala grass had been more effective than fallow, while the application of pig manure had no additional effect. The latter is more or less in accordance with findings of Oostenbrink (20), who observed that stable manure had no effect on the incidence of the potato root eelworm in the *absence* of the host plant. He assumes that the suppressing influence of manure on parasitic eelworms in the *presence* of host plants is rather due to a greater resistence of the plants than to an effect of the decomposition products, because the non-parasitic forms were less affected than the parasitic ones. Also Van Der Laan (25) concluded that plants treated with organic materials such as manure and compost develop some resistance to nematodes, perhaps due to physiological changes in the plant itself.

A further trial was carried out to determine the influence of the incorporation of organic matter on the eelworm population. In this case loppings of marigolds, *Tephrosia* and dadaps were mixed with soil infested with both meadow and root-knot eelworms (1 lb. loppings in 40 lb. soil). The mixture was put into cement pots, there being 6 pots for each treatment; 12 pots containing infested soil only, of which 6 were fumigated, serving as controls. All pots were regularly watered and kept free of weeds.

Three assessments on the eelworm population were made during the course of the experiment, the results of which have been presented in table 2.

TABLE 2.—*The effect of the incorporation of organic matter on the eelworm population of fallow soil; expressed in number of eelworms per* 600*g soil* (6 *samples of* 100 *g.*)

Treatments	26 Nov., 1957*		3 Feb., 1958		13 Sept., 1958		
	Pr.	Mel.	Pr.	Mel.	Pr.	Mel.	Oth.
Control: not fumigated ...	102	683	81	20	16	4	1541
Control: fumigated ...	107	669	1	2	1	1	2239
With marigold loppings ...	97	87	33	4	4	0	6739
With dadap loppings ...	73	71	17	7	2	0	13737
With *Tephrosia* loppings ...	66	95	20	7	3	3	14736

*Date experiment started; Pr. = Pratylenchus; Mel. = Meloidogyne; Oth. = Other nematodes.

The table shows that the *Pratylenchus* and *Meloidogyne* populations had notably decreased in all treatments about 2 months after the experiments started. The eelworm content of the fumigated soil was almost nil, while the non-fumigated

control still contained a considerable number of meadow eelworms as compared with the pots with loppings. About 7 months later a similar trend existed, but the number of parasitic eelworms had further decreased.

It is worthy of note that the number of non-parasitic eelworms in the pots with the loppings was very much greater (statistically significant) than in the pots without. Lindford *et al* (16) suggest that the increased population of total nematodes, brought about by the decomposition of organic material, assists the building up of a micro flora and fauna destructive to nematodes. Soil organisms, *e.g.* certain fungi (6) have in fact been found to be predatory on eelworms.

It can be concluded that the incorporation of organic matter to some extent depresses the development of the parasitic eelworm population in the host plant whether directly or indirectly. It is therefore good agricultural practice to provide tea fields with organic matter in the form of loppings, thatch, compost or manure both from a point of view of soil improvement and on account of its adverse effect on harmful eelworms.

4. Cover crop and shade trees with respect to eelworm susceptibility.

The effect of cover crops, green manures and shade trees with respect to eelworm infestation may be twofold. On the one hand, they may assist in diminishing eelworm infestation, in so far as they are eelworm resistant and serve as providers of organic material. On the other hand, their influence may be unfavourable in cases where they are susceptible to attack by the same eelworms which are detrimental to the main crop. The relation between the susceptibility of the preceding crop and the degree of infestation of the crop grown thereafter has been amply demonstrated by Oostenbrink (21). He found that if the first crop had been severely attacked by eelworm, the crop grown in succession would be infested likewise, or *vice versa*. For instance, the subsequent growth of roses and apple seedlings, which plants are susceptible to *Pratylenchus*, greatly depended on the susceptibility of the crops which were grown in the two preceding years.

It is possible that likewise in tea, the population levels of *Pratylenchus* and *Meloidogyne* are to some extent affected by the degree of susceptibility of plants previously cultivated or intergrown with tea. Accordingly we have listed below a number of plant species the susceptibility of which to meadow and root-knot eelworms is approximately known.

Grasses and weeds.—Of the former, Guatemala grass (*Tripsacum laxum*) is the most important as it is widely used for soil-reconditioning. Following earlier observations (28) it was recently (26) confirmed that this grass is practically immune to both meadow and root-knot eelworm, thus explaining the depressing effect of its cultivation on these eelworms in the soil. From inoculation trials done by Gadd (15) it would appear that Mana grass (*Cymbopogon confertiflorus*), paspalum grass (*P. dilatatum*) and carpet grass (*Axonopus compressus*) are also resistant to meadow eelworm.

Among the weeds, *Polygonum nepalense* (15) is probably resistant, while *Oxalis corymbosis* is slightly susceptible to meadow eelworm. The latter was found to be highly susceptible to *Meloidogyne arenaria* (26).

Cover crops.—*Stylosanthes gracillis* and *Drymaria cordata* appeared to be largely resistant to both meadow and root-knot eelworm; *Mimosa invisa* is moderately susceptible to the latter but not to the former (27). *Desmodium gyroides* is fairly resistant to *P. coffea* (12, 14), but not to *M. incognita* (5).

Marigold varieties of the species *Tagetes erecta* and *T. patula* deserve special mention. Both the investigations of Oostenbrink *et al* (22) and Meyneke *et al* (19) and experiments carried out at the Institute (26) proved the effectiveness of marigolds in suppressing the *Pratylenchus* and *Meloidogyne* populations in the soil. Their nematocidal action was found to equal that of fumigants; as such, marigold cultivation can be effectively adopted as a measure of eelworm control.

The large semi-wild varieties (probably varieties of *T. erecta*) found in Ceylon grow vigorously on fallow tea soil, but are less successful as a cover crop in mature tea (after pruning), growing only moderately under such conditions.

Bush crops.—Previous (10, 12, 13, 14) and recent findings (28, 29) indicated that *Crotalaria anagyroides* and *C. usuramoensis* are not attacked by either meadow or root-knot eelworm (*M. javanica*). The latter species as well as *C. juncea* have been found susceptible to *M. incognita* var. *acrita*; *C. striata* and *C. retusa* appear resistant (23), *C. spectabilis* used as a pre-crop has been shown to reduce the severity of root-knot eelworm in tobacco grown subsequently (18). Apparently, eelworm resistance is a feature of many species of this genus[1] and thus their cultivation is useful in infested areas.

Numerous investigations (8, 9, 26, 27) have confirmed that *Tephrosia vogellii* is susceptible to meadow eelworm and even more so to root-knot eelworm and is therefore not recommended to be planted in tea. It is possible that other species of *Tephrosia*, like *T. eriosemoides* and *T. toxicaria* could be used, for Gadd (15) ascertained from inoculation trials that these species were not invaded by meadow eelworm. *Sesbania cinerescens* shows some susceptibility to meadow and root-knot eelworm (27) though it does not appear to be adversely affected, as this species grew well in infested soil.

Shade trees.—*Gliricidia maculata*, *Tecoma stans* and *Grevillea robusta* when mature appear to be resistant to meadow and root-knot eelworm (27). The last mentioned was found to be susceptible to root-knot eelworm in the seedling stage only (10). *Albizzia moluccana*, *Acacia decurrens* and *Calpurnia aurea* showed a slight susceptibility to meadow eelworm but were not or only slightly infested by root-knot eelworms (27). *Erythrina leucosperma* (7, 9, 27) and *Albizzia sumatrana* (15, 27) must be listed as only slightly susceptible to meadow eelworm, but very susceptible to root-knot eelworm. However, whereas Albizzias appear to be tolerant to root-knot eelworm attack, dadap is often found to be adversely affected and to degenerate as a result.

The picture which emerges from the above—partly based on preliminary observations—is that a fair number of plants grown in tea are not or only negligibly susceptible to *Pratylenchus coffea*. Even those plants, which have been listed to be more or less susceptible to this eelworm have usually been found to harbour markedly less eelworms than tea. Whereas roots of the former category may contain 20–70 worms per 10g, roots of tea growing in similar soil may carry hundreds or even thousands of eelworms per sample. Apparently, the great majority of cover plants and shade trees are far less congenial hosts for *Pratylenchus* than tea.

With respect to *Meloidogyne* infestation, a number of plants appear to be highly susceptible to this genus. In most instances, but possibly not in all, as determination is fairly difficult, the species involved is, unless otherwise mentioned, *M. javanica*.

Mature tea has not been found to be susceptible to *Meloidogyne* species except in rare instances (*M. brevicauda*). It appears to be susceptible (to *M. javanica* and *M. incognita*) at a young stage only; it may be inferred from observations that a well grown tea plant of 6—7 months old is already immune. The same possibly holds true for a number of other plants (*e.g. Grevillea*). It is advisable, therefore, to take precautions against infestation in the nursery stage.

Finally, it can be said that as far as mature tea is concerned, the use of root-knot eelworm-susceptible cover crops and/or trees is not likely to be harmful to tea. However, one may encounter difficulties, *e.g.* in the case of dadaps, in establishing such plants in infested soil. In such instances it may be wiser to plant resistant plant species.

5. The effect of soil fumigation.

1. **In mature tea.** Soil fumigation is an obvious means of control of eelworms. Of a number of fumigants like Shell DD, Nematox 100 and Nemagon, tried out,

[1] A chemical compound responsible for this resistance has been identified by investigators in the Netherlands (oral information.)

only the last mentioned appeared to be suited for mature tea as the two former were found to be strongly phytotoxic. Nemagon applied in the field at the recommended rate per acre, of 10 gallons diluted to about 40 gallons by adding kerosene, was found to have no adverse effect on mature tea bushes (27). When applied at double this rate (20 gallons —20 gallons kerosene) some of the older leaves became scorched, but otherwise no damage occurred.

With regard to its effectiveness on eelworms, it appeared from a preliminary trial with Nemagon on infested tea at St. Coombs, that following fumigation at rates of 5, 10, 20, 30 and 40 gallons per acre moderate re-infestation of the soil occurred about 2, 7, 9, 10 and 11 months later, respectively.

Larger scale field trials were carried out on blocks of $\frac{1}{2}$ to 1 acre of infested tea in its 2nd or 3rd year after pruning on Eildon Hall, Wootton, Kirimetiya and Dambatenne estates, respectively. The Nemagon-kerosene mixture (1 : 3) was injected into the soil (6″ deep) with an injector gun on 4 sides of the bush at 10 ml. per side. The fumigation was carried out in February-March, 1957. Its effect was assessed by monthly examination of 25 soil samples (100 g each) from each area respectively; the last sampling was taken in July, 1958.

It appeared that fumigation at Dambatenne estate had not been very effective, as the number of parasitic eelworms had been reduced to only about half, following fumigation. On the other 3 estates the meadow eelworm population was virtually nil for a limited time after fumigation. The general trend of re-infestation by meadow eelworm after fumigation on these estates is shown in figure 1. This figure presents "the degree of infestation with time" as expressed in the number of soil samples per 25 examined which were found to be free of meadow eelworm at different times.

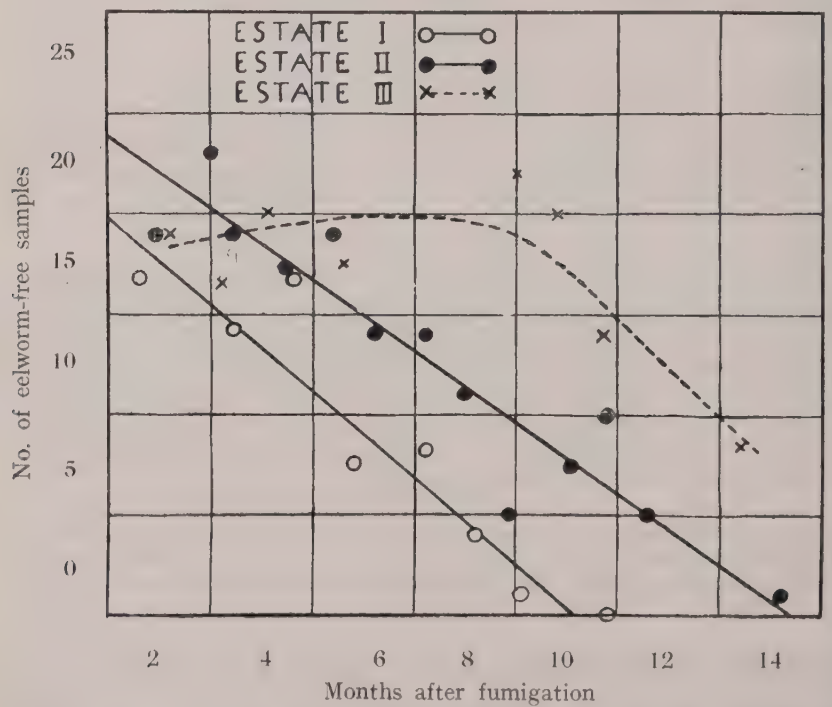

Figure 1. The re-occurrence of meadow eelworm infestation after fumigation with Nemagon as expressed in number of eelworm-free samples per 25 examined.

The relation between re-infestation and time on two estates (Eildon Hall-I and Wootton-II) is a linear one (the regression is highly significant). That is to say, the number of samples found to be free of eelworms decreases linearly with time. After about 9 months on estate I and 13 months on estate II *all* soil samples (25/time) contained a small number of meadow eelworms. On estate III (Kirimetiya) the picture was somewhat different as up to about 9 months after fumigation the majority of samples were still free of eelworms. Even after 13 months not all samples showed infestation and those which did, contained very few eelworms only.

The greater effectiveness of fumigation on the last estate as compared with the two other estates, is possibly due to differences in the organic matter content of the soil, fumigation being more effective if the organic matter content is lower. It is quite possible that this has been the case as the soil conditions at the one estate are poorer than those at the others.

On one estate separate yield records of the fumigated plot ($\frac{1}{2}$ acre) and the rest of the field (24 acres) were kept by the Superintendent. These data are presented in table 3.

TABLE 3.—*Yield of a fumigated plot in comparison with that of an untreated area*

	Yield in lb. fresh leaf per acre	
	Not treated	Fumigated
March, July, August	218	200 (91.7)
September, October, November ...	238	300 (126.1)
December, 1957; January, 1958; February ...	366	516 (141.0)
March, April, May	393	486 (123.7)
June, July, August, September	323	430 (133.1)
Total for 1 year after pruning: September, 1957–August, 1958	1487	1886 (126.8)

N.B.—Figures within parenthesis denote the yields of the fumigated plot as percentages of those of the untreated area.

Table 3 shows that the yield over the first three months following fumigation (in early March; pruning in April) was somewhat less than that of the untreated area. Thereafter, the treated plot yielded considerably more per acre than the rest of the field. Notwithstanding that the areas compared are very different in acreage and that analysis of the figures is not possible, the observed yield trend indicates that fumigation favourably affected subsequent yield.

The field trials show that fumigation at the recommended rate keeps the eelworms in check for not much longer than one year, or even for a shorter interval, depending on the soil and weather conditions at the time of and immediately after fumigation. The favourable effect on yield would probably last for a longer period. It is clear, however, that fumigation would have to be repeated at least once every pruning cycle in order to prevent undue re-infestation. Under the circumstances, therefore, fumigation of mature tea cannot be envisaged as a means of control in practice, as the costs—in the order of Rs. 800/- per acre—are prohibitive.

II. In nurseries.—Extensive experiments on the effect of soil fumigation on *Meloidogyne* species (*M. incognita*) in seedling nurseries have been carried out by the Tocklai Experimental Station with methyl bromide (1, 2) and Shell DD (2, 3, 4, 5) at rates of 200 to 400 lb. per acre and with Nemagon (5) at 2 and 4 gallons per acre. The results appeared to be variable; in many instances the original population had been reduced to 10–15% of the original level but sometimes the reduction amounted to only 35–50% one month after fumigation. In general, fumigation did not prevent the majority of seedlings (sown 4–6 weeks following fumigation) becoming infested by root-knot eelworm. However, infestation was often less and growth better, though not markedly so, than that of the controls, when assessed 6–8 months after soil fumigation.

The results obtained with fumigation in Ceylon seem to be on the whole more favourable than those obtained at Tocklai. It appeared from one of the field trials (26), that young tea plants planted in a fumigated area (2 weeks after treatment with Shell DD at 10 gallons/acre) carried, 7 months later, about twice as many leaves as control plants growing in a non-fumigated plot (57 versus 29 leaves per plant); the meadow eelworm population of the former plot was only 7% of that of the former area. One year after fumigation the differences in growth were even more marked, but the soil of the fumigated area carried at the time as many meadow eelworms as that of the non-fumigated plot (71 versus 73/sample).

An experiment carried out with Nemagon at rates of 3, 4 and 5 gallons (made up to 40 gallons by adding kerosene) in an infested nursery carrying young tea plants gave the following results (average number of eelworms from 5 samples) presented in table 4.

TABLE 4.—*Effect of soil-fumigation with Nemagon at different rates on eelworm populations.* (*5 ml. every sq. ft.*)

Treatments	7 months after fumigation		9 months after fumigation	
	Pr.	Mel.	Pr.	Mel.
Control	20	0	67	0
Nemagon at 3 gall./acre ...	2	2	11	0
,, ,, 4 ,, ,, ...	4	2	10	10
,, ,, 5 ,, ,, ...	0	0	1	10

Pr. = *Pratylenchus*; *Mel.* = *Meloidogyne*.

The figures show that while fumigation with 5 gallons Nemagon per acre had kept both meadow (Pr.) and root-knot (Mel.) eelworm down for 7 months, the lower concentrations were less effective. After 9 months re-infestation became evident in all treatments, but the number of meadow eelworms was still much less than that of the control though more root-knot eelworms were present. These results more or less tally with those of the field experiments described in the previous paragraph—*viz.* that re-infestation of the soil at a moderate level may be found within 7 months after fumigation, if the soil *carries tea throughout*. Under such circumstances soil re-infestation is bound to occur as Nemagon is of doubtful effectiveness as regards the killing of eelworms *living in* the tea roots. Fumigation is not fully effective in the presence of host plants.

Indeed, fumigation never kills all eelworms, so that it is advisable to leave the soil fallow for some time, resulting in the weakening or death of the surviving eelworms by starvation.

With respect to the length of such a period, Gadd (14) ascertained from experiments, in which meadow eelworms were kept in humid sand, that only 20% had survived after 18 weeks. However, at the end of 9 weeks, although 45% of the eelworms had survived starvation, none of the survivors were able to enter the roots of *Tephrosia vogellii* seedlings.

In our fumigation trials the percentage of surviving eelworms in a fallow soil has been found to be only a fraction of the above survival figure, usually varying between 1 and 5% one to two months after fumigation. Accordingly if one allows a minimum of 10 to 14 weeks after fumigation before cuttings or young plants are planted, it is unlikely that after the lapse of such a period any virile parasitic eelworms would remain, especially if soils with a low initial eelworm population were used. The latter condition is actually an essential one which can be adhered to by using "virgin" soils only.

A better alternative to the fumigation of nurseries which appears to be promising, is the cultivation of marigolds, preferably together with that of Guatemala grass. By doing so, eelworm control and reconditioning are achieved simultaneously.

Summary and conclusions

From the information available it would seem that meadow eelworm infestation is fairly widespread, presumably more so at up-country than at lower elevations. However, the pest appears to be latent in many instances; in those cases where infestation has become acute, losses in crop can be estimated at 250 lb. tea/acre/year. The fact that tea is a monoculture of long standing and a number of other features, *e.g.* age, unsatisfactory bush and soil management, etc. are likely to have contributed to the aggravation of the eelworm problem.

There is reliable experimental evidence that the incorporation of organic matter, in the form of loppings, compost and manure will assist in reducing the effects of eelworm infestation. Presumably, the influence of organic matter is primarily indirect, *viz.* by increasing the resistance of the plant and improving soil conditions, while a direct depressing effect on the eelworm population must also not be ruled out.

A fair number of cover crops, green manures and shade trees associated with the cultivation of tea appeared to be more or less immune to meadow eelworm and not very susceptible to root-knot eelworm. The susceptibility of these plants to the latter is probably no danger to tea over one year old as by then the crop appears completely resistant. The planting of *Tephrosia vogellii* is not recommended because of its susceptibility to both eelworms. The cultivation of marigolds shows promise as an effective means of eelworm control in nurseries or in fallow tea soil.

Soil fumigation in mature tea can depress eelworm infestation considerably but for a limited time only. Its effect on yield was found to be favourable. The fumigation of tea fields is not practical on account of its prohibitive cost. Fumigation of nurseries is advisable in cases where no regular replacement of the worn-out soil by virgin and/or eelworm-free soil is possible. It is recommended that the soil be left fallow for a period of 10 to 14 weeks after fumigation in order to weaken any surviving eelworms.

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NOTES ON THE DISTRIBUTION AND BIOLOGY OF THE LYGUS BUG—*LYGUS VIRIDANUS* MOTSCH—(HETEROPTERA-MIRIDAE), A PEST OF TEA IN CEYLON

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Introduction

Species of the genus *Lygus* are widely distributed and are pests of economic importance in many parts of the world. In Ceylon, six species of the genus have been recorded. Of these six species, *L. decoloratus Dist.* and *L. viridanus* Motsch. have been recorded on tea (1).

L. decoloratus has been recorded as a pest of tea in Bogawantalawa (6,000 ft.) by E. E. Green as early as 1904 (1). Since then no record of *Lygus* as a pest of tea appears to have been made until B. N. Webster, in 1954, investigating a "corroded flush" symptom on tea in plucking, formerly attributed to the "Cercosporella" disease, showed that a capsid bug, *Lygus viridanus* Motsch. was responsible for the damage (3). Once the symptoms of the attack were recognised and associated with the pest, reports of infestations of *Lygus viridanus* continued to reach the Tea Research Institute. It is quite probable, however, that some of these reported attacks of *L. viridanus* may have been caused by *L. decoloratus*. Nevertheless, recent observations indicate that of the two species *L. viridanus* is the more common pest on tea.

The *Lygus* bug is not one of the common pests of tea, however, and rarely does it cause extensive damage. Sporadic outbreaks of the pest appear to have occurred in the years 1956 and 1957.

Hitherto, there is no available record of published information on the bionomics of *Lygus viridanus* Motsch. This paper outlines its distribution and briefly describes the biology of the species.

Distribution

Lygus viridanus Motsch. appears to be endemic to Ceylon, but its distribution is confined to the cooler and more humid parts of the hill country. It is a common pest on ornamental plants in up-country bungalow gardens and is prevalent as a pest of tea, on some estates, above an elevation of about 4,000 ft. *Lygus viridanus* is usually found in the Maskeliya, Dimbula, Dickoya, Nuwara Eliya, Haputale, Badulla and Bandarawela districts. However it is more commonly found in the Maskeliya and Dimbula-Dickoya districts. The distribution on estates is indicated by the following list:—

LIST OF ESTATES SUBJECTED TO LYGUS ATTACKS

Dickoya and Maskeliya Districts

	Estate	Elevation	Locality	Reported Outbreaks Year	Month
1.	Alton	4,700′	Upcot	1956	May
				1957	April
2.	Gartmore	—	Maskeliya	1957	April
				1958	April-May
3.	Heidri	—	Rozella	1955	April
4.	Robgill	4,500′–6,600′	Bogawantalawa	1957	August
5.	Laxapana	*5,051′	Maskeliya	1953	February
				1954	April
				1956	May
				1957	May
				1958	May
6.	Lethenty	*4,000′	Hatton	1957	April
				1958	December
7.	Loinorn	—	Hatton	1957	February
				1958	December
8.	Moray	*4,053′	Maskeliya	1957	May
				1957	April-May
9.	Theresia	*4,300′	Bogawantalawa	1956	December
10.	Tillyrie	*4,539′	Dickoya	1955	April
				1957	September

Dimbula-Nuwara Eliya Districts

11.	Ardlaw	4,500′–5,000′	Agrapatna	1956	June
12.	Caledonia	*4,400′	Lindula	1956	June
13.	Glenlyon	*4,500′	Agrapatna	1957	July
14.	Gonapitiya	*6,000′	Kandapola	1956	April-May
					June-Sept.
15.	Hoomwood	*5,200′	Agrapatna	1957	July
16.	Oliphant	—	Nuwara Eliya	1957	August
17.	Scrubs	6,100′–6,900′	Nuwara Eliya	1956	June
				1957	September
				1958	May
18.	Somerset	4,500′–5,000′	Talawakelle	1956	April
19.	Strathspey	4,400′–5,000′	Talawakelle	1955	April
20.	Torrington	4,600′–6,500′	Agrapatna	1956	June

Badulla, Bandarawela & Haputale (Uva)

21.	Balagalla	*4,900′	Glen Alpin	1956	June
22.	Beauvais	*4,800′	Idalgashinna	1956	August
23.	Nayabedde	*6,100′	Bandarawela	1957	March-April
24.	Udaveria	4,000′–7,000′	Ohiya	1956	April

Lygus infestations on tea estates are usually confined to "top fields," with an elevation of about 5,000–6,500 ft. Invariably the infested fields border jungle or lie close to the jungle and since it has been found that most of these jungles too were infested with the bugs, it is quite probable that they are the sources of infestation.

*Elevation-factory site.

In the tea fields the bugs are usually confined to small "pockets" or "depressions" close to ravines or to the jungle.

Damage due to *Lygus* may occur throughout the year, but is more common in April, May and June.

Description and life history

The adults of the bug, as the name *viridanus* indicates, are green in colour, with a slight yellowish tinge and are rather delicate insects. The females and males are similar in general appearance, the males being on average slightly smaller than the females and of a paler green colour. The length of the females ranges from 0.15″ to 0.2″ approximately. The wings give the insect a slightly larger appearance, as they cover the whole of the abdomen and extend about 0.04″ beyond the tip of the abdomen. The outer pair of wings forms a triangular iridescent apex, when the insect is at rest, which is covered with fine black hairs. The head is distinct and has large black eyes. The antennae are as long as the body. The proboscis lies flexed beneath the body when the insect is at rest.

The females can be easily distinguished from the males by the presence of the ovipositor which appears to the naked eye as a small brown streak on the mid ventral line of the abdomen. The ovipositor when at rest lies nearly concealed in a groove on the ventral side of the abdomen.

The females lay their eggs within the tender tissue of the host plants. They are embedded, singly, in the tender parts of the plants such as stem, petiole and leaf mid-ribs. A single female lays 1–12 eggs per day.

The eggs when freshly laid measure 0.9mm. in length and 0.25mm. in breadth. The egg is cylindrical, rounded at the posterior extremity, obliquely truncated towards the apex, which ends in a distinct egg cap—the only part of the egg visible above the surface of the stem. In a freshly laid egg the egg cap is visible to the naked eye as a pale yellow spot, flush with the surface of the stem. In development the egg swells in size and the egg cap is pushed out above the surface of the stem and appears as a brownish convex cap, which later turns white in colour.

The egg takes 13–20 days to hatch, the duration of the egg-stage varying with climatic conditions. When hatching takes place, the fine fibrillae that attach the egg cap to the egg case break, and the nymph slowly wriggles out. The nymph on immediate emergence is covered with a fine membrane, which it splits open and casts off.

There are five nymphal growth stages or 'instars' and the developing nymph moults after each instar, the adult insect appearing from the final moult. The average length of the different instars is 1st 0.95 mm, 2nd 1.2 mm, 3rd 1.6 mm, 4th 2.1 mm and 5th 3 mm. Rudiments of the wings ('wing-pads') appear in the 3rd instar, developing in size in the 4th and 5th instars to appear as functional wings in the adult. All instars of the nymph, and the adults, feed by sucking sap from the buds, tender shoots and leaves. The nymphal period takes about 3 weeks. Adults live for a period of 2–3 months.

Habits and damage to host plants

In their habits *Lygus* bugs show much resemblance to other sucking bugs such as *Helopeltis theivora*. They have been observed to feed during all times of the day. It has been recorded that they feed by night too (Webster, 1954). During the day the bugs avoid the direct rays of the sun. They remain within the ground cover or within the tea bushes during hours of sunshine and come out to feed in

dull and cloudy weather. They thrive well in warm and moist weather, and the "misty" condition in most "top fields" of the higher elevations (5,000–6,500 ft.) is most suitable for the bugs. The bugs are swift fliers and their flight is characterised by short flights to distances of 2–3 yards at a time; nevertheless they can also fly distances of 30–40 yards.

Lygus viridanus attacks only the young and succulent tissue of plants, notably young buds and tender leaves. Older tissues of plants, such as mature leaves and stems are not attacked. The bug feeds on the sap of the host plants with its long proboscis, which is inserted into the tender tissues of the buds and young leaves. The insect's saliva has in it a toxic property, which kills the cells of the tissue around those that have suffered mechanical damage as the result of the insertion of the proboscis; so that, on freshly attacked flush these areas of dead cells appear as small brown spots of about 1 mm in diameter. When the buds open and the leaves enlarge, as a result of cell expansion, no corresponding expansion takes place in the small areas of dead cells, resulting in the formation of small holes in the more mature leaves. When feeding punctures are made along the inrolled margins of the buds and when such buds open, the margins of the leaves are found to be wavy or "corroded." Very often the tender buds that are attacked die, with the result that many "flushing points" are lost and when this is repeated it brings about a stunted effect on the tea bush, resulting in severe loss of crop. Very often the damage caused by *Lygus* bugs is not noticed till weeks after the attack, as the "corroded leaf" appearance becomes evident only when the buds open and the young leaves mature, so that the "corroded leaf" is no indication of *Lygus* damage at that particular time of inspection. To determine whether a tea field is being attacked by *Lygus* bugs one should look for "fresh attack" in the form of fresh punctures on the young buds and tender leaves, which appear as very small brown spots.

Host plants

Lygus viridanus Motsch. has been observed to feed on a large number of wild plants in the jungle bordering the infested tea estates, the most common being *Eupatorium odoratum*, *Solanum auriculatum* Ait. and *Solanum feron* L.

They also feed on *Tibouchia semidecondra*, *Polygonium repalanse*, *Tithonia diversifolia*, *Lantana sp.*, *Crotalaria walkeri* Arn. *Strobilanthes kestitus* Nees. In bungalow gardens they are a pest on *Salvia*, *Geranium*, *Verbina*, *Coletus*, *Tropaecolum* and *Hibiscus*. On estates they also attack *Tecoma stans*, a shade tree, and cover crops such as *Drymaria cordata* and *Oxalis corymbosa*. Of the tea plant they show preference for low jat tea. Observations have shown that in the presence of more suitable host plants like *Salvia*, *Lygus viridanus* does not attack tea plants. Attempts to breed the bugs on tea in St. Coombs exclusive of all other host plants, have been unsuccessful. This would suggest that the tea plant is only a casual host of the pest; nevertheless a more detailed investigation would be necessary to determine this.

Methods of Control

To date the control methods adopted for *Lygus* infestations are:—

1. Hard plucking.
2. Spraying with D.D.T.

Recent observations have shown, however, that hard plucking alone may not be an effective means of *Lygus* control, since the eggs are not deposited on the tender shoots only but below the "fish leaf" as well.

The application of D.D.T. has proved to be effective, when applied in the concentration of 1 lb. 50% D.D.T. Wettable Powder in 25 gallons water and at the rate of 100 gallons of spray fluid per acre. One such application should be sufficient in good weather, but should the symptoms of fresh punctures be observed two weeks after the first application, a second application would be desirable. The D.D.T. spray can be confined to the attacked patches of tea alone, but care should be taken to spray the ground cover and weeds by the side of ravines and jungle borders to ensure maximum kill of the pest.

It should be noted that the use of D.D.T. on other crops has in some cases resulted in the increase of other pests due to the destruction of natural insect enemies. At present there is insufficient evidence on this aspect of the use of insecticides on tea, and it is receiving attention. Pending further work, the use of D.D.T. on strictly limited areas to control severe *Lygus* infestation is considered justified. The removal of the above mentioned wild plants, which are alternate hosts of the pest, from jungle borders and ravines would help a great deal in the prevention of an infestation.

Acknowledgment

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REVIEW OF THIRTY YEARS STUDY OF TEA DISEASES IN CEYLON

D. Mulder

Introduction

Although the main function of a research worker is to look ahead and plan experiments for the future, it is good to look back now and again, to see what has been achieved in the past and what practical conclusions have resulted from the research carried out. Repetition can thus be avoided and promising lines of work that have been started and then dropped can be picked up again. Research on a subject such as agriculture has necessarily to be productive of practical result, but frequently this entails a fundamental study of the problem to provide the basis for arriving at practical conclusions.

Literature

Before T. Petch started research on the diseases of tea in Ceylon, Watt and Mann had written a book in 1903 on the "Pests and Blights of the Tea Plant" in India, in which a dozen diseases are described. Later, most of the root, stem and leaf diseases of tea in Ceylon were described by Petch in 1923 in his book "The Diseases of the Tea Bush." Petch worked in the Department of Agriculture as Mycologist from about 1907 to 1926 and was the first Director of the Tea Research Institute of Ceylon (1926–1928). Sixty diseases of tea were described in his book.

Since the work of Petch, the number of new tea diseases investigated has been relatively small. The major achievements were in the fields of physiological disorders, eelworm diseases and virus diseases. In Monograph No. 2 of the Institute on 'The Commoner Diseases of Tea' written by the first Mycologist of the Institute, C. H. Gadd, in 1948, we find about 20 important diseases described.

Review

When we review the Annual Reports of the Tea Research Institute since 1926, it is interesting to note how the emphasis on particular problems has changed in the course of the years.

In 1926 Gadd considered the Cercosporella leafspot disease as most important. There is no doubt that as Acacias, which are also susceptible to this fungus, were more numerous as shade trees then, the tea was more severely infected with it than nowadays. A second problem studied was that of chlorosis. Gadd discerned different types and identified at least one cause for the condition when he found that the sap of chlorotic leaves was much less acid (pH about 6.0) than that of healthy leaves. He concluded that the kind of chlorosis under consideration was due to too high a soil pH. This led him in 1927 to conduct experiments on the water culture of tea seedlings, whereby he established the importance of the pH of the medium for the good growth of tea.

The prevalence of *Poria* root disease was recognised from early times and research on methods of control started. As far back as 1930 the advice for the control of Poria root disease was the uprooting of a ring of healthy bushes around the diseased ones. In 1936 work on this disease was crowned with the conclusion drawn from pot experiments with *Tephrosia vogelii* that, if soil is completely freed from roots infected with Poria, it is not infectious any more.

This was one of the main subjects of investigation of the Pathology Division from 1927 till 1939; thereafter phloem necrosis and eelworms became the more important lines of study. *Armillaria* root disease was first mentioned in 1927, but fortunately it never became as important here as in East Africa.

The importance of the amount of food reserves in the root system in connection with recovery from pruning was recognised about this period. For instance, the incidence of dieback, until then attributed to *Diplodia* root rot at mid and low elevations, was instead linked with lack of food reserves.

In 1926 Gadd had mentioned the occurrence of a kind of witches broom in tea. This condition became an important subject of research in the years 1930–33. Gadd tried to relate it to the symptoms of sulphur deficiency or yellows of tea in East Africa, but abandoned the idea when he found that sulphur-containing fertilizers had no influence on the incidence of witches broom. It was, however, not established at what depths the intake of nutrients and water mainly occur during the period of witches broom growth and how deep the sulphur-containing fertilizer penetrated during the period of observation. The question of the relation of this condition with yellows of tea remains therefore unsettled. Experiments on transmission were also unsuccessful. The cause of the disease remains unknown even today. It would appear that the incidence of witches broom in tea has diminished since 1933. It may be that a change in fertilizer practice has led to higher soil acidities and thereby to a decrease of the disease.

In 1936 phloem necrosis virus disease was mentioned for the first time as a serious and spreading disease on up-country estates above 4000 ft. Its cause remained unknown till 1939. Gadd suggested 'curly leaf' as its popular name. This suggestion could not be adopted however, as it was found that many bushes reveal necrosis in the bark without showing any outward symptoms.

In 1936 also polyclady was described. It might be of interest to note the symptoms of this condition in detail. They are:

1. prolific production of small whippy branches from the ground,
2. leaves small and hard,
3. branches wiry and close together—hardly a main frame,
4. roots turn upwards and give rise to numerous branches,
5. a large number of shoots stay below soil level and occur as white, spirally curled stems.

Judging from the symptoms, the disease might be caused by a virus.

1937 is marked by the first mention of eelworms in tea (root-knot eelworm). Research on the subject continued and in 1939 the much more important meadow eelworm was discovered in old tea.

On the work on phloem necrosis during the intervening period, the hypothesis that a virus was the cause was enunciated in addresses given by Gadd to Planters' Association meetings up-country. He disclosed during one discussion that a transmission experiment by inarching had given definite proof that phloem necrosis was caused by a virus. Gadd suggested the appointment of a specialist for this subject, and from 1940–1944 T. E. T. Bond studied the problem intensively. Summarising Bond's studies we can draw the following conclusions:—

1. Numerous transmissions of the virus by grafting gave definite proof of the virus nature of this disease.
2. The spread of the virus in the plant is slower than the elongation of a fast-growing shoot.
3. The necrosis persists in new growth from necrotic cuttings.
4. In a field on St. Coombs a 10% increase of diseased bushes was found during one year.
5. Rogueing is a possible method of controlling the spread of phloem necrosis.
6. A diseased scion can be grown on a healthy seedling-rootstock, without this rootstock starting to show symptoms, due to the tolerance of this seedling-rootstock towards the virus (symptomless carrier).
7. No proof of seed transmission is available and no insect vector has been found.
8. High jat material can act as a symptomless carrier for the virus.
9. Its occurrence in the field discloses both a discontinuous spread and a bush-to-bush spread.

In August, 1945, with the departure of Bond research on phloem necrosis ceased.

Mycological work in 1940 led to the discovery of *Pleiochaeta albizziae* (Petch) Hughes as the cause of a serious leaf disease of Albizzia seedlings in the nursery, and of the presence locally of the fungus related to tea scab *Elsinoe theae*, as identified by South American research workers.

In the years 1941–1946 the study of nematodes in tea was one of the main lines of work done by Gadd and Loos.

In 1946 blister blight made its first appearance in Ceylon. In the years following the whole of the activities of the Pathology Division was concentrated on this major problem. In 1947 it was known that cuprous oxide could be used for the control of this disease, but it was doubted whether it would be economic to spray the whole tea crop as a preventive measure. In 1948 the study of the life history of blister blight was continued and in 1949 the first spraying experiments against blister blight were started.

During the first blister blight Symposium in 1949 the control measures advocated were summarised by G. B. Portsmouth and C. A. Loos. Spraying was only advised for pre-tipping fields and nurseries. The other control measures suggested were changes in cultural practices and the selection of resistant clones. In 1950 the problem of controlling blister blight became very urgent and the Shell Company decided to send its pathologist at the Amsterdam laboratory to the Institute to study control measures during the south-west monsoon. As a result of his studies, copper emerged as the most suitable of the fungicides for the purpose.

In 1950 a second blister blight Conference was held and the idea of "crop protection" was introduced. This meant that instead of only protecting pruned fields and nurseries the whole crop had to be sprayed. Many experiments were done by Loos and B. N. Webster in 1950 and 1951 on spraying regularly throughout the monsoon with a fungicide and by 1952 spraying with copper compounds was general practice on almost all up-country tea estates.

When it had been found that the spraying of copper was effective and economic, numerous other fungicides and spraying, dusting and mist blowing techniques were tried out, partly with the help of commercial firms. It was shown however that copper fungicides were ideal for the purpose because the low quantity

of copper used does not affect the colour or the flavour of the tea and has a favourable effect on fermentation. During severe monsoon conditions, spraying provided the only definite answer to the problem of blister blight control, dusting being a good alternative under more favourable weather conditions.

The first stage in the studies on the control of this disease was concluded in 1955 with the publication of a pamphlet on the "Protection of Ceylon Tea from Blister Blight" by Portsmouth and Webster.

The initial advice of spraying pruned fields and nurseries only, has been extended to the recommendation of spraying the whole estate regularly from two plucking rounds before the onset of the monsoon to the end of the rainy season.

In 1955 a revival of eelworm research took place; the search for resistant clones was started under the direction of Loos who became the first eelworm specialist in the Institute. When he left his work was continued by T. Visser, who became acting Pathologist in 1957 on the departure of Webster. In regard to findings on this subject, it has been shown that soil disinfection with eelworm-destroying chemicals (nematocides) is too expensive for large scale work in the field, but that it can be carried out in the nursery. A new possibility was put forward by Visser when he showed that the marigold (*Tagetes* sp.) has the capacity of killing eelworms through one of its root excretion products.

1957 was the last year of the testing of commercial fungicides for blister blight control by the Institute. The latest development in the control of this disease took place in 1958 when it was shown that sunshine is the most important factor for the inhibition of spore germination. Experiments on a method of forecasting blister blight on the basis of sunshine records were then started.

Major achievements

When we review the major achievements of the Institute in connection with the diseases of tea we may summarise them as follows:—

1. Parasitic root and leaf diseases were studied intensively before the establishment of the Institute, but control measures as for instance against Poria were worked out by the Institute.
2. Witches broom was studied for a number of years, but the cause remained unknown, although some circumstances stimulating its development were revealed.
3. The blister blight disease was studied intensively and efficient measures of control were developed; costs remain high, however. A new method of timing the spraying based on sunshine records may enable the industry to economise on this item.
4. The problem of meadow eelworm has been studied for a long time but the final solution has not yet been found, although the prospects for the use of cover crops like marigold appear hopeful. Selection of clones for resistance gives good results. A method for the fumigation of nurseries was worked out.
5. The phloem necrosis virus disease was identified in 1939 and studied for five years thereafter. In 1945 the work was discontinued. Research was resumed in 1958.
6. Dieback and wood-rot have been studied since 1926 until now and a number of weak parasites related to these troubles have been described. No definite method of control has, however, been found as this trouble is not a pathological problem but the result of bad cultural practices in the past and of shot-hole-borer attack.

GUATEMALA GRASS ROOTS IN SOIL REHABILITATION

J. A. H. Tolhurst

When consideration is given to the growing of a cover crop for rehabilitating soil after tea has been uprooted. attention naturally tends to be focussed on the visible parts of the crop, the foliage. We have always emphasised that the root action of such a crop is just as important, if not more so, as the effect of the lopped foliage. Presentation of a few simple analyses may serve to bring home our contentions more clearly.

Hershall samplers were used to extract cores of soil from the top six inch layer in areas representing varying climatic conditions and soil types. The cores of soil were allowed to dry on the laboratory bench, after the larger clods were broken by hand to pass through a half inch mesh sieve. Stones retained by the sieve were discarded. After drying, as many as possible of the guatemala grass roots were removed by hand, dried at 98°C in an oven and weighed. On the assumptions that a cylindrical core of soil 6 inches deep and 4 inches in diameter weighs approximately 3 pounds and that an acre of field soil to a depth of 6 inches would weigh, if dried, approximately 2 million pounds, the following conversion was made:—

$$\text{Weight of roots, in ounces, per core} \times \frac{2{,}000{,}000}{48}$$

= Weight of dry roots, in pounds, per acre of 6 inch top soil.

If desired, the same operation could be carried out for the soil layer between 6 and 12 inches depth, of course, and in some fields this would no doubt give surprisingly high weights of the grass roots. However, as the aim of these very simple experiments was to suggest methods of analyses which could be done on estates with no difficulty and with readily available standard equipment, it was decided to concentrate attention on the more important and more vulnerable top soil.

The centres from which samples were taken were:

Centre A. Dimbula: 4,500 feet; annual rainfall 90 inches. Site A at this Centre represents a steep, wind swept slope, more subject to drought than sites B, C or D, and had been planted with guatemala grass eight years earlier on virgin patana. Site B, which showed a decidedly more vigorous growth of grass, had been planted two years previously after old tea which had given a good cover. Site C represented a small area of over-cultivated garden soil which had been under the grass for three years. This period included a replanting of the grass, which had been exceptionally vigorous, one year before the present samples were taken.

Site D was quite exceptional in being a steep bank of sub-soil thrown out from a building site. When planted under the grass three and a half years previously the raw sub-soil, from an original depth of 10 to 15 feet, was hardly in a condition which could properly represent soil.

Centre B. Maskeliya: 4,500 feet; annual rainfall 120 inches, more uniformly distributed than Centre A. The effect of wind was also more moderate.

The area had been under guatemala grass for one year, following the uprooting of the old tea, which had given a very close cover.

Centre C. Lower Hewaheta: 3,000 feet; annual rainfall 95 inches; more exposed to drying wind than either of the previous centres. Sites A and B had both been planted in guatemala grass for one and a half years following tea which, for pathological reasons, had not provided a good soil cover.

All the sites examined had been regularly manured, and in more recent years, in certain sites, very generously. The accumulation of large grass roots is shown in table I.

TABLE I.—*Accumulation of large guatemala grass roots in the top 6 inch layer of rehabilitated soil*

Centre	Site	Dry weight of roots	Compost equivalent
		Approximated to tons per acre	As tons of fresh weight
A	A	$3\frac{3}{4}$	15—19
	B	5	20—25
	C	$4\frac{1}{2}$	18—22
	D	10	40—50
B		5	20—25
C	A	3	12—15
	B	15	60—80

Compost is such a variable commodity that only a rough approximation can be attached to the figures in the second column, but they are likely to be underestimates of the fresh weight equivalent as compost. They also provide an interesting basis for a practical evaluation of the grass root content. It should be remembered that, in this particular analysis, no account was taken of the very fine grass roots, which appeared to be most abundant in the top inch or two of the soil, nor of the humus resulting from death and decay of some of the roots produced early in the establishment of the grass.

An additional benefit to be derived from rehabilitation with a cover crop is to be seen in the tendency for a rehabilitated soil to have a definite crumblike structure, as opposed to a loose, powdery, structure all too common in soils which have been exposed to the full force of climatic extremes. Measurement of this effect is more difficult than the estimation of the addition of grass roots to a soil. Nevertheless, yet another attempt has been made to arrive at a very elementary approximation of a full scientific analysis. If a quantity of fresh soil is placed on a 2 millimetre mesh sieve, which is then submerged in a bucket of water and rotated gently about twenty times, it will usually be found that some of the soil remains on the sieve. Stones will also remain, and must be taken into account when estimating the weight of soil retained by the sieve. Crude though this analysis may be, it can give a practical illustration of the aggregating effect of the grass roots.

The following figures in table II will illustrate some comparative effects:—

TABLE II.—*Simple estimation of the aggregation of soil by guatemala grass roots; top 6 inch layer*

Centre	Site	Percentage of soil retained by a 2 mm. sieve. Stones excluded
A	B	32
	Tea adjoining B	24
	D	21
	Raw sub-soil	0
C	A	29
	Tea adjoining A and B	18
	B	34

Inspection of these results and also those in table I will show that quite wide variations in the measurable effects of the guatemala grass have been found, which do not correlate very closely with climatic conditions or the length of the rehabilitation period. No general conclusions must be sought for in such preliminary work, which was, in fact, directed deliberately at variations in the areas rehabilitated. Two points do merit special mention. The raw sub-soil, Centre A, Site D, after a short period under the grass has been brought into a condition where it is recognisable as soil and not merely weathered rock. Both sites in Centre C were on a loose, gravelly soil, of which Site A was doubtless the more susceptible to drought, and here the effect of the grass roots on the soil was more pronounced than the appearance of the leaf growth would have led one to expect.

A straightforward chemical analysis of the total organic matter of a soil, before and after rehabilitation, would be of little value as a practical tool for estimating the progress of the rehabilitation. The acquisition of many tons of "humus" in the six inch top soil would represent such a small increase in the analytical figure for total organic matter, which includes forms less active than "humus," that the detection of the increment would tend to be obscured by the errors introduced by sampling. It may even be found that the microbial decomposition of the original organic matter, stimulated by the upheaval of uprooting, may continue for a long period, giving a soil which has, excluding the large grass roots, less organic matter after rehabilitation than before. Analyses have been obtained which, allowing for sampling error, show this decrease.

In conclusion, it is suggested that the two physical analyses described may allow an estimation of some of the important effects of cover crop rehabilitation, and may well be found to be within the capacity of the staff of an estate. As usual, we must stress that a soil analysis can only properly be evaluated when it has been correlated with actual results in the field. Individual experimenting is again called for, and until the Institute is in a position to do detailed, on the spot, surveys and analyses we shall have to rely on the compilation of the efforts of individual estates in order to arrive at more general conclusions and eventually make general recommendations on the details of the rehabilitation process.

Appendix

The scheme for the soil sieving analysis is as follows:—

(*a*) Sieve the fresh soil through a $\frac{1}{2}$" mesh sieve as gently as possible to remove stones and large roots. Do not crush the soil crumbs more than is absolutely necessary, and do not let the soil dry out.

(*b*) Take a small portion of this soil for determination of moisture at 100°C.

(*c*) Spread 1 pound of the fresh soil evenly on a sieve of 2 mm. mesh and about 6 inches diameter, submerge gently in a bucket of water and rotate twenty times with a slight vertical movement in addition.

(*d*) Dry the residue remaining on the sieve at 100°C and weigh.

(*e*) Take the dried residue after weighing, crush the soil so that it falls through the 2 mm. sieve and weigh the remaining small gravel.

(*f*) Percentage aggregation is then calculated from the dry weight of the original soil sample, as derived from (*b*):—

$$\% \text{ Aggregation} = \frac{\text{d} - \text{e}}{\text{Dry weight of sample} - \text{e}} \times 100$$

MISCELLANEOUS NOTES

+ APPLICATION OF GROWTH SUBSTANCES ON CLONAL CUTTINGS

K. V. S. Krishna

In order to assess the suitability of root-growth-promoting substances on tea cuttings on a commercial scale, experiments have been designed and carried out by Mr. K. V. S. Krishna at Katary Estate, Nilgiris, India. His experiments, results, and conclusions have been forwarded to us for publication in the *Tea Quarterly*. Since similar experiments have been conducted by us to determine the effect of growth-promoting substances on tea cuttings, the results of which have been already published in the Annual Report of the Plant Physiologist of the Institute for 1957, it was thought useful to summarise his experiments, results and conclusions with comments.

He used two hormone preparations, AB 8000 (a solution of Indolylacetic Acid (IAA) and Indolylbutyric Acid (IBA) in 50% alcohol, containing equal parts of IAA & IBA, the total growth substance concentration being 8000 p.p.m.) and Seradix B, a proprietary powder, and untreated cuttings as control.

In all 10,000 cuttings of 44 clones were under test. The 3 treatments AB 8000, Seradix B-2, and control were tested out on every clone tried. Planting was done in August, September and November, 1958, respectively, with a view to assess both the seasonal and hormonal effects on the rooting of tea cuttings. Experimental errors were kept to a minimum by using similar soil, shading and watering in all tests. The cuttings were dipped in the AB 8000 solution for 2 seconds, while care was taken to see that an uniform quantity of Seradix B-2 powder went with each cutting. Assessment was done after a period of 110, 150, and 100 days for August, September and November planting, respectively. The cuttings were examined and the number rooted, callused and dead were recorded.

TABLE I.—*Total effect of month of planting and treatments*

	ROOTING %			
	AB 8000 —	Seradix A-2	Control —	Avg. % —
August ...	(111.4) 49	(86.4) 38	(100) 44	43.7
September ...	(130.8) 68*	(126.9) 66*	(100) 52	62.0
November ...	(96.4) 80	(97.6) 81	(100) 83	81.3
Total ...	197	185	179	187.0
Average % ...	65.7	61.7	59.7	62.3
% Increase on Control	110	103	100	

Figures within parenthesis denote results in percentages of control (100%).
* Significant at 5% level.

+ *The Institute does not necessarily endorse the views expressed in papers contributed by persons other than members of the Staff.*

Results

Table I gives the total effects for the month of planting and hormone treatments. The increase or decrease by the use of AB 8000 and Seradix is not statistically significant in the case of the August and November experiments, while the increase over the control in the September planting by using hormones is significant at the 5% level. November planting has given the best results, due most probably to the excessive rain of 12.66″ experienced during the August and September experiments against 5.89″ in November. Excessive rainfall, coupled with lack of drainage during August resulted in a high percentage of cuttings which showed excessive callusing.

TABLE II.—*Summary of mean rooting percentages of clones in groups*

	Control	AB 8000	Seradix
*(5) 20% ...	12.0 (100)	45.8 (382)	41.2 (343)
*(9) 21—40% ...	33.9 (100)	42.0 (124)	34.0 (100)
*(8) 41—60% ...	51.0 (100)	60.3 (118)	56.5 (111)
*(7) 61—80% ...	70.6 (100)	78.4 (111)	78.4 (111)
*(6) 81—90% ...	87.3 (100)	76.8 (88)	77.7 (89)
*(9) 91% ...	98.8 (100)	89.1 (90)	84.7 (86)

* No. of clones used.

In table II, the clones have been grouped into categories according to the rooting percentages of the control. It will be noticed that only the very poor rooting clones (those below 20%) responded markedly to the treatments. This response is highly significant. The response in the case of the better rooting categories is much less and decreases with an increase in the rooting capabilities of the clones, until with good rooters giving over 90% rooting there appears to be a slight depressing effect by hormonal treatment, although this effect is not significant.

Summary

(1) Cuttings planted in November have given better results than those planted in August and September.

(2) There is a significant response by poor rooting clones to these hormones, but this response decreases as the rooting percentage of the clones increases until, with very good rooters, there appears to be a depressing action on rooting. The former were defined as "positive," the latter as "negative" clones.

Comments

These experiments have unfortunately not been replicated and this reduces considerably the value of the figures obtained. This lack of replication is however partly compensated for by the great number of clones used. Although the results indicate that November planting is superior to planting in August and

September, it would not be strictly correct to attribute this result to the month of planting because different clones were used in the three experiments which might partly account for the increase in rooting obtained in November. The results of these experiments confirm those obtained by us, namely, that the use of growth-promoting hormones, although they tend to increase rooting in poor rooting clones, have not given results that will justify their use on a commercial scale except in some special cases. In special cases, *e.g.* to promote the propagation of material with valuable characteristics, like resistance to pests, outstanding quality, etc., hormone treatment may be useful.

(Summary and comments by L. M. de W. Tillekeratne, Plant Physiology Division).

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* THE ADOPTION OF A THREE-YEAR PRUNING CYCLE AT GALLINDA ESTATE, TALGASWELA, GALLE DISTRICT

B. Warusavitarne

A three-year pruning cycle is practised on a few tea estates primarily because of the incidence of shot-hole borer. Others adopt the 18 month cycle for the same reason. On Gallinda estate, in the Galle District, which has a good, well-distributed rainfall, a three-year cycle has been adopted for the past 6 years, although the reason for this is *not* the control of shot-hole borer, which is negligible in this area.

The pruning adopted was somewhat harder than the cut-across which is commonly practised in the low-country. The manure mixture used was T. 521 which contains a higher proportion of potash than the T.R.I. T. 500. Manuring was done at the time of tipping and at intervals of 4 months thereafter on the basis of 12 to 15 lb. of nitrogen per 100 lb. of crop produced. Plucking was on the slope, and a year after pruning a harder plucking was adopted.

The results in the attached table would show that a three-year pruning cycle is feasible in the low-country, although it is not claimed that the yield increases during the period are due to this factor. That it may have contributed to the result cannot be overlooked. Generous manuring has certainly been largely responsible for the improved yields obtained. The figures underlined give yields obtained between the 18th and 30th month from pruning.

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* *The Institute does not necessarily endorse the views expressed in papers contributed by persons other than members of the staff.*

GALLINDA ESTATE-TALGASWELA

THREE, YEAR PRUNING CYCLE RECORDS

	YIELD PER ACRE												Yield per	
Field No.	1	2	3	4	5	6	7	8	9	10	11	12	Acre for	Rainfall
Year of Planting	1922	1913	1924	1924	1925	1927	1928	1930	1932	1946	1947	1948	Estate	Inches
1952	—	—	—	—	—	—	—	—	—	—	—	—	558	124
1953	—	—	—	—	—	—	—	—	—	—	—	—	708	141
1954	—	—	—	—	—	—	431	259	174	—	—	315	750	152
1955	—	212	220	139	—	—	1007	1004	950	187	—	833	788	165
1956	349	802	902	959	308	383	**1095**	**1249**	**1035**	1258	335	**971**	868	139
1957	866	**810**	**868**	**963**	863	1026	261	250	393	**1377**	1457	407	926	130
1958	**708**	633	654	641	**857**	**993**	—	—	—	911	**1738**	—	1103	161
1959	180	—	—	—	242	550	—	—	—	—	697	—	—	—
Total for 36 Months	2103	2457	2644	2702	2270	2952	2794	2762	2552	3733	4227	2526		
Average per year	701	819	881	900	756	984	931	920	850	1244	1409	842	—	149

MINUTES OF THE MEETING OF THE BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON HELD IN THE CHAIRMAN/COMMITTEE ROOM OF THE PLANTERS' ASSOCIATION OF CEYLON, COLOMBO, ON FRIDAY, 5th JUNE, 1959, AT 2.30 P.M.

Present.—Messrs. F. Amarasuriya (Chairman) G. I. de Glanville (Chairman, Agency Section, Planters' Association of Ceylon), H. Creighton (Chairman, Planters' Association of Ceylon), C. Selwyn Samaraweera (Chairman, Low-Country Products Association), D. G. L. Misso, C.C.S. (Acting Deputy Secretary to the Treasury), B. Mahadeva, C.C.S. (Tea Controller), G. K. Newton, R. J. Gilmour, R. M. Macintyre, J. L. D. Peiris, D. E. Hettiarachchi, E. Jayawickreme, W. H. W. Coultas, R. C. P. Adams, J. N. Atkinson, Dr. A. W. R. Joachim (Director) and Mr. G. A. D. Kehl (Secretary).

1. Notice convening the meeting was read.

The Chairman welcomed Messrs. de Glanville, Adams and Atkinson to the Board.

2. **Minutes of the Meetings held on 6-3-59 and 10-4-59**

The minutes were confirmed.

3. **Matters Arising out of the Minutes**

(i) **Minutes of 6th March, 1959.**

(*a*) Item 6 (i)—Mutwagalla Estate

The Director reported that acquisition proceedings had been proceeding satisfactorily and that enquiries had been concluded. There were certain issues yet to be resolved which the Institute's lawyers were dealing with. This matter would be discussed at the next meeting of the Low-Country Sub-Station Committee and then brought up before the Board. He hoped that the estate would come into the possession of the Institute by about the end of August.

(*b*) Item 8 (iv)—Co-operative trials

The Director reported that the question of purchasing land in close proximity to St. Coombs was being considered by the staff, but any decision thereon will be deferred till after the arrival of the new Director.

(*c*) Item 8 (viii)—Packing materials

Mr. Keegel's memo dated 4th May, 1959, was read.

(*d*) Item 11 (i)—Visit of Minister

Reported that the Hon'ble Mr. Phillip Gunawardena visited the Institute on 18th April, 1959.

(*e*) Item 8 (v)—Technology Division

In reply to Mr. Macintyre the Director said that the vote of Rs. 50,000/- was for a set of 6 rollers and a drier for each of the proposed 6 V.P. units, each set costing approximately Rs. 7,000/-.

(ii) **M eeting of 10th April, 1959**

Reported that Dr. Gunn had accepted the post of Director and that a cable was received intimating that he was sending his resignation from his present post.

4. **Membership of the Board and Committee**

(i) **Board**

(*a*) Reported that Mr. G. I. de Glanville had succeeded Mr. P. W. Keun as Chairman of the Agency Section of the Planters' Association of Ceylon as from 11th April, 1959.

(ii) **Committee**

Mr. R. M. Macintyre was acting for Mr. R. D. Wedd on the Administrative Committee as from 1st April, 1959, and would take the place of Mr. G. K. Newton on the Appointments Committee on his retirement.

5. **Minutes of the Meetings of the Administrative Committee held on 6th March, 25th April and 23rd May, 1959**

(i) **Meeting of 25th April, 1959.**

The following recommendation was approved:—

(*a*) Page 5, Item 6—Building programme

The acceptance of Messrs. M. Y. Hemachandra & Company's tender for the new stores to serve as a shopping centre for the staff.

(*b*) Page 6, Item 6 (*d*)—Water Supply

Reported that Mr. Gibbs had examined the three tenders for the Stage II of the water scheme and had recommended the acceptance of Messrs. Walker Sons & Company's tender. As the tenders were closed on 4-3-59, it was possible that there might be an increase in the tendered figures due to rise in prices. There would also be an additional expense of approximately Rs. 5,000/- to put into effect the recommendation of the Administrative Committee for increasing the capacity of the treatment plant. The Administrative Committee was authorised to deal with the matter.

(*c*) New Buildings

It was noted that arrangements were ready for calling for a block tender for the following buildings:—

One Senior Staff Bungalow
One Senior Staff twin maisonette
One Intermediate Staff Bungalow
Four Junior Staff Grade Bungalows

(ii) **Meeting of 23rd May, 1959**

The following recommendations were approved:—

(*a*) Page 1, Item 3 (i) (*b*)—Visiting Agent, St. Coombs

Mr. Newton spoke on this matter and suggested the appointment of Mr. Alexander Mackie as Visiting Agent, St. Coombs. Proposed by Mr. Coultas, seconded by Mr. Newton.

(*b*) Page 1, Item 3 (i) (*b*)—Superintendent, St. Coombs

The revised terms to be offered to the new Superintendent, St. Coombs (Appendix A to Administrative Committee minutes).

The Chairman thanked Mr. Newton on behalf of the Board for the valuable services he had rendered to the tea industry in general and to the Tea Research Institute in particular, in his capacity as a member of the Board for many years and as its Visiting Agent of St. Coombs for the past 7 years. He wished him and Mrs. Newton every happiness.

Mr. Newton thanked the Chairman for his kind sentiments expressed, which he much appreciated and said that he would closely associate himself with the tea industry and Institute while in London.

(*c*) Page 3, Item 4—Provident Fund

The Administrative Committee be authorised to decide on the amounts to be paid in enhancement of the provident fund of the officers concerned and to make the payments in the case of retired officers. Papers to be circulated to the Board thereafter for their information.

(*d*) Page 3, Item 5—Scientific Advisory Board in the U.K.

The acceptance of Dr. Tubb's memo with the provisos suggested by the Administrative Committee and the payment of a composite fee to Dr. Tubbs.

On the proposal of the Director, the Board recorded its appreciation of all the help Dr. Tubbs had given the Institute and himself in matters concerning the recruitment of staff, for formation of the U.K. Advisory Committee, etc., on which his assistance had been sought.

(*e*) PAGE 2, ITEM 3 (iii)—DR. S. C. PEARCE

The Director reported that Dr. Pearce left Ceylon on the 17th May. He had submitted the draft of his report which had been typed and sent to him for amendment and final approval. This would be submitted to the Experimental and Estate Committee for consideration. It would be arranged that a summary of the technical aspects of his report be published in the *Tea Quarterly*.

The recommendations of the Administrative Committee were accepted and the minutes of the meetings of the 6th March, 29th April and 23rd May, 1959, were approved.

6. Minutes of the Meetings of the Appointments Committee held on 7th and 23rd May, 1959

(i) **Chief Advisory Officer—Mr. C. B. Foster-Barham**

The appointment of Mr. C. B. Foster-Barham as Chief Advisory Officer was approved. Mr. Foster-Barham was due to assume duties about the beginning of October.

(ii) **Plant Breeder**

The Director reviewed the position in regard to this appointment. The Appointments Committee had considered the matter that morning, and as no suitable candidates were available, recommended that the assistance of the United States Operation Mission to Ceylon be obtained in securing the services of an experienced Plant Breeder as in the case of the Nematologist. Agreed.

It was agreed in this connection that a reciprocal arrangement should be made with the University of Ceylon by which applications from officers of the two institutions should be forwarded through the Heads of their respective institutions.

7. Minutes of the Experimental and Estate Committee held on 9th May, 1959

(i) **Page 4, Item 5—Development Engineer**

It was agreed to refer the matter of the appointment of a Development Engineer to the U.K. Scientific Advisory Committee for their views.

(ii) **Page 5, Item 6—Visiting Agent's Report—Tea Seed & V.P. material**

The Board endorsed the resolution of the Committee in regard to its policy on the use of V.P. material and tea seed for replanting purposes and directed that a copy of this resolution be forwarded to the Planters' Association before its meeting on the 16th June when this matter was to be discussed.

Mr. Mahadeva said that the Tea Subsidy Scheme Board would reconsider the matter when they had received the views of both the Planters' Association and the Low-Country Products Association on this subject.

The recommendations of the Experimental and Estate Committee subject to the amendment under item (i) above were approved and the minutes noted.

8. Finance

(i) Institute's Accounts to 30th April, 1959

In regard to the item Rs. 511,379.38 shown in the Balance Sheet as a liability on Small Holdings Advisory Service, it was stated that this represented the total as at 30th April. When items which still required settlement had been attended to, the balance would be written off as previously decided by the Board.

The Accounts were approved.

(ii) Audited Accounts and Report for 1958

The Administrative Committee was authorized to scrutinise the audited accounts and report when received, and approve the accounts for publication in the Annual Report for 1958. The recommendations of the Committee with the Auditors' report and accounts were to be circulated later to the Board.

9. Staff

Reported that—

(i) Mr. J. A. H. Tolhurst, Agricultural Chemist

Mr. Tolhurst had been on medical leave since 22nd May and that he will be away from duty till 24th June.

(ii) Mr. G. D. Austin, Entomologist

Mr. Austin was on four months full pay leave from 1st May prior to retirement.

(iii) Mr. J. E. Cranham, Entomologist

Mr. Cranham arrived in Ceylon on 22nd April and assumed duties.

(iv) Chief Administrative Officer, Mr. H. J. Balmond

Mr. Balmond was expected to assume duties as Chief Administrative Officer on 1st July, 1959.

(v) Research Assistants

(*a*) Mr. D. Calnaido, Research Assistant in Entomology, and Mr. N. Shanmuganathan, Research Assistant in Pathology, had proceeded on Colombo Plan

scholarships to further their studies at the Rothamsted Experimental Station and East Malling Research Station respectively.

(*b*) Mr. M. Selvaratnam, Research Assistant in Agricultural Chemistry, resigned his appointment as from 31st May to take up an appointment at the University.

(*c*) **Research Assistant in Nematology**

Mr. R. A. Jayatillake, B.Sc. (Hons.) had assumed duties on 1st June.

(*d*) **Grade II Appointments**

The following assumed duties:—

(1) Mr. G. A. S. Gunasinghe, Assistant-Stenographer/Typist as from 1st March.

(2) Mr. W. J. Samuel, Assistant Accounts Clerk, as from 1st May.

(3) Mr. E. O. Stuart, Junior Staff Grade II-B (Agricultural Chemistry Division) as from 1st May.

10. **Any Other Business**

(i) **Royal Entomological Society, London**

Reported that the Registrar of the above Society had acknowledged with thanks the contribution towards the publication of Dr. K. E. Schedl's paper entitled "A check-list on the *Scolytidae* and *Platypodidae* of Ceylon" in the Society's transactions.

(ii) **Research Institutes**

A letter from the Chairman of the Rubber Research Institute suggesting that a Committee consisting of the three Chairmen and the three Directors of the three Research Institutes be formed to deal with the question of dearness allowance to certain grades of officers was tabled. The Board agreed to the proposal and nominated the Chairman and Director to serve on the Committee.

(iii) **Next Meeting**

The next meeting of the Board was fixed for Friday, 4th September, 1959, at 9 a.m. in Colombo.

Sgd. *G. A. D. KEHL,*
Secretary.

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